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**UTILITY  
PATENT APPLICATION  
TRANSMITTAL**

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No. 566.38616X00

First Inventor or Application Identifier Kousuke ANZAI

*Title* See 1 in Addendum

*Express Mail Label No.*

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

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(preferred arrangement set forth below)			
	<ul style="list-style-type: none"> <li>- Descriptive title of the Invention</li> <li>- Cross References to Related Applications</li> <li>- Statement Regarding Fed sponsored R &amp; D</li> <li>- Reference to Microfiche Appendix</li> <li>- Background of the Invention</li> <li>- Brief Summary of the Invention</li> <li>- Brief Description of the Drawings (<i>if filed</i>)</li> <li>- Detailed Description</li> <li>- Claim(s)</li> <li>- Abstract of the Disclosure</li> </ul>		
<input checked="" type="checkbox"/> X	Drawing(s) (35 U.S.C. 113)	[Total Sheets	18
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a. <input checked="" type="checkbox"/> X	Newly executed (original or copy)		
b. <input type="checkbox"/> X	Copy from a prior application (37 C.F.R. § 1.63(d) ( <i>for continuation/divisional with Box 16 completed</i> )		
i. <input type="checkbox"/> X	<u>DELETION OF INVENTOR(S)</u> Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b)		

5.  Microfiche Computer Program (Appendix)

6. Nucleotide and/or Amino Acid Sequence Submission  
(if applicable, all necessary)

- Computer Readable Copy
- Paper Copy (identical to computer copy)
- Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

7.  Assignment Papers (cover sheet & document(s))

8.  37 C.F.R. §3.73(b) Statement  Power of  
(when there is an assignee)  Attorney

9.  English Translation Document (if applicable)

10.  Information Disclosure Statement (IDS)/PTO-1449  Copies of IDS  
Citations

11.  Preliminary Amendment

12.  Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)

13.  \* Small Entity  Statement filed in prior application  
Statement(s)  Status still proper and desired  
(PTO/SB/09-12)

14.  Certified Copy of Priority Document(s)  
(if foreign priority is claimed)

15.  Other: Figs. 1-12,13A-13B,14-18

\* **NOTE FOR ITEMS 1 & 13 IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).**

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Priority claim information: \_\_\_\_\_ Group (Art Unit: \_\_\_\_\_)

*Prior application information:* Examiner *Group / Art Unit:* \_\_\_\_\_

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**METHOD FOR EMBEDDING INFORMATION AND EXTRACTING THE SAME**

**CROSS-REFERENCES TO RELATED APPLICATIONS**

This application claims priority from Japanese

5 Patent Application No. 11-153672 filed on June 1, 1999 and  
No. 11-75007 filed on March 19, 1999, the entire contents  
of which are incorporated herein by reference for all  
purposes. This application relates to the U.S. Patent  
Application 09/388,447, filed on September 2, 1999, which  
10 claims priority from Japanese Patent Applications No. 10-  
343119 filed on December 2, 1998, No. 11-075006 filed on  
March 19, 1999, and No. 11-153385 filed on June 1, 1999.

**BACKGROUND OF THE INVENTION**

15 The present invention relates to a technique of  
digital watermarking of digital data, in particular,  
multimedia data such as image data.

Recently, the technique of digital watermarking has  
20 the attention from the viewpoint of copyright protection of  
multimedia data such as image data. By the technique of  
digital watermarking, given information is embedded in  
multimedia data, and that given information can not be  
extracted from the multimedia data in question at least  
25 without employing a given rule. Using this technique,  
information, for example, on a purchaser of image data is

embedded in an invisible form in the image data itself according to a given rule. When the data is copied illegally, then, by extracting the embedded information from the illegally-copied data according to the above-5 mentioned given rule, it is possible to specify a person (i.e., the purchaser) who has carried out the illegal copying.

Image data having embedded digital watermark information may be subject to various image processing such 10 as shifting, scaling, and rotation. Thus, it is desired that a given information can be extracted from multimedia data even in those cases.

#### SUMMARY OF THE INVENTION

15 According to the present invention, even if image data having digital watermark information has been subjected to the above-mentioned image processing, it is possible to specify positions in which the digital watermark information is embedded, in the image data in 20 question.

The present invention provides a method of embedding digital watermark information, in which image data is divided into a plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels, and each bit of digital watermark 25 information  $b_1 - b_n$  ( $2 \leq n$ ) is embedded in at least one of the mentioned plurality of areas S, wherein:

the mentioned digital watermark information  $b_1 - b_n$  is embedded in the image data such that:

a plurality of groups, each having a predetermined array consisting of areas  $T_1 - T_n$  in which the mentioned 5 digital watermark information  $b_1 - b_n$  is respectively embedded and areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is not embedded, are located according to a predetermined rule; and

each of the mentioned areas  $S$  is allocated to some 10 one of the mentioned areas  $T_1 - T_n$  and  $H_1 - H_m$ .

According to the above-described mode of the invention, the groups  $G$  each having the predetermined array consisting of the areas  $T_1 - T_n$  in which the digital watermark information  $b_1 - b_n$  is respectively embedded and 15 the areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is not embedded, are located according to a predetermined rule, in such a manner that each of the areas  $S$  obtained by dividing the image data is necessarily allocated some one of the mentioned areas  $T_1 - T_n$  and  $H_1 - H_m$ .

20 Thus, even when image shift (i.e., processing of changing the origin in the X-Y coordinates for specifying a location of each pixel constituting the image data in question) is carried out on the image data in which the digital watermark information  $b_1 - b_n$  is embedded in such a 25 manner, and accordingly, the locations of the areas  $T_1 - T_n$  in which the digital watermark information is embedded are

changed in the X-Y coordinates, it is possible to recognize each of the groups located on the image data by detecting the areas  $H_1 - H_m$  in which information is not embedded, in the areas  $S$ , and based on the values of X-Y coordinates of 5 the detected areas  $H_1 - H_m$  on the image data. In each group, the areas  $T_1 - T_n$  in which digital watermark information  $b_1 - b_n$  is respectively embedded and the areas  $H_1 - H_m$  in which the digital watermark information is not embedded are located in the predetermined arrangement. As 10 a result, for each group, it is possible to specify the areas  $T_1 - T_n$  in which the digital watermark information  $b_1 - b_n$  is respectively embedded.

Further, the present invention provides a method of embedding digital watermark information, in which image 15 data is divided into a plurality of areas  $S$  each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels, and each bit of digital watermark information  $b_1 - b_n$  ( $2 \leq n$ ) is embedded in at least one of the mentioned areas  $S$ , wherein:

a plurality of groups, each having a predetermined 20 array consisting of areas  $T_1 - T_n$  in which the mentioned digital watermark information  $b_1 - b_n$  is respectively embedded, areas  $J_1 - J_k$  ( $1 \leq k$ ) in which information  $p_1 - p_k$  specifying an embedding format for embedding the digital watermark information  $b_1 - b_n$  in said areas  $T_1 - T_n$ , and 25 areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is not embedded, are located according to a predetermined rule; and

each of the mentioned areas S is allocated to some one of the mentioned areas  $T_1 - T_n$ ,  $J_1 - J_k$ , and  $H_1 - H_m$ ; in embedding the mentioned digital watermark information  $b_1 - b_n$  and the mentioned information  $p_1 - p_k$  specifying the 5 mentioned embedding format, in the image data.

According to the above-described mode of the present invention, the groups, each having the predetermined array consisting of the areas  $T_1 - T_n$  in which the digital watermark information  $b_1 - b_n$  is respectively embedded, the 10 areas  $J_1 - J_k$  in which the information  $p_1 - p_k$  specifying the embedding format for the mentioned digital watermark information  $b_1 - b_n$  in the mentioned areas  $T_1 - T_n$  is embedded, and the areas  $H_1 - H_m$  in which information is not embedded, are located according to the predetermined rule 15 such that each of the areas S obtained by dividing the image data is necessarily allocated to some one of the mentioned areas  $T_1 - T_n$ ,  $J_1 - J_k$ , and  $H_1 - H_m$ .

Thus, even when image shift is carried out on the image data in which the digital watermark information  $b_1 - b_n$  is embedded in such a way, and accordingly, X-Y 20 coordinate locations of the areas  $T_1 - T_n$  in which the digital watermark information  $b_1 - b_n$  is embedded are changed, it is possible to recognize each of the groups located on the image data by dividing the image data on 25 which this image shift has been carried out into a plurality of areas S and by detecting the areas  $H_1 - H_m$  in

which information is not embedded from the areas  $S$ , and based on the X-Y coordinates values of the detected areas  $H_1 - H_m$  on the image data.

Further, in the present mode, for each group, the  
5 information  $p_1 - p_k$  specifying the embedding format for the digital watermark information  $b_1 - b_n$  in the areas  $T_1 - T_n$  is embedded in the areas  $J_1 - J_k$ . Accordingly, even when an embedding format for the digital watermark information  $b_1 - b_n$  is changed for each group, it is possible to extract the  
10 digital watermark information  $b_1 - b_n$  from the image data.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more apparent from the following detailed description, when taken in conjunction  
15 with the accompanying drawings, in which:

Fig. 1 is a block diagram showing an digital watermark information embedding apparatus 1 used in a digital watermark system to which an embodiment of the present invention is applied;

20 Fig. 2 is a view for explaining an operation principle of a block dividing part 103 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 3 is a view for explaining an operation  
25 principle of an information embedding part 104 of the digital watermark information embedding apparatus 1 shown

in Fig. 1;

Fig. 4 is a view for explaining the operation principle of the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 5 is a view for explaining the operation principle of the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 6 is a view for explaining the operation principle of the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 7 is a view showing an example of the hardware configuration of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 8 is a flowchart for explaining operation of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 9 is a block diagram showing a digital watermark information extracting apparatus 3 used in a digital watermark system to which an embodiment of the present invention is applied;

Fig. 10 is a view for explaining an operation principle of a group recognizing part 304 of the digital watermark information extracting apparatus 3 shown in Fig.

9;

Fig. 11 is a view for explaining the operation principle of the group recognizing part 304 of the digital watermark information extracting apparatus 3 shown in Fig. 5 9;

Fig. 12 is a flowchart for explaining operation of the digital watermark information extracting apparatus 3 shown in Fig. 9;

Figs. 13A and 13B are flowcharts for explaining a 10 difference in processing burdens between the case (Fig. 13A) in which the method of repeating the same transformation processing as the left-right reversal, scaling processing, and rotation processing that might have been carried out on image data until the digital watermark 15 information  $b_1 - b_n$  is extracted from the image data is applied to the transformation by image shift processing and the case (Fig. 13B) in which the mentioned method is combined with the extract method of the present embodiment;

Fig. 14 is a view for explaining a variation of a 20 location pattern for groups G on image data, used in the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 15 is a view for explaining a state in which reversal processing has been carried out on the image data 25 having the location pattern of the groups G shown in Fig. 14;

Fig. 16 is a view for explaining a state in which 180-degree rotation processing has been carried out on the image data having the location pattern of the groups G shown in Fig. 14;

5 Fig. 17 is a view for explaining a principle of embedding and extracting information in and from image data by a digital watermarking technique; and

10 Fig. 18 is a view for explaining problems in information embedding and extracting processing on image data by a digital watermark technique, in the case that 10 image shift has been carried out on the image data.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 Fig. 17 is a view for explaining a method of embedding and extracting information in and from image data by a digital watermarking technique.

20 As shown in the figure, in information embedding processing, with respect to each bit  $b_i$  ( $0 \leq i \leq n$ ) out of bits  $b_1 - b_n$  constituting information that is desired to be embedded, brightness of each of pixels positioned in predetermined areas  $Q_1 - Q_m$  in the image data is changed to increase by  $U$  when the bit in question is 1, and to decrease by  $U$  when it is 0. By carrying out this processing for every bit  $b_1 - b_n$  while changing positions of 25 the areas in which the bit in question is embedded, digital watermark information is embedded in the image data.

In processing of extracting the above-mentioned embedded digital watermark information, with respect to a bit  $b_i$  ( $0 \leq i \leq n$ ) out of the bits  $b_1 - b_n$  constituting the embedded information, an average brightness  $F$  of pixel data 5 is obtained for each of the above-mentioned predetermined areas  $Q_1 - Q_m$  of the image data, so as to obtain the sum total  $\Sigma F$  of these averages. Further, an average brightness  $R$  of pixel data is obtained for respective peripheral areas adjacent to the above-mentioned predetermined areas  $Q_1 - Q_m$ , 10 so as to obtain the sum total  $\Sigma R$  (Reference Value) of these averages. When  $\Sigma F - \Sigma R \geq Th$  (where,  $Th$  differs depending on required error rates, and here it is assumed that  $Th = 1/2 \times U \times m$  ( $m$ : the number of the areas  $Q$  in which  $b_i$  is embedded) ), then it is judged that  $b_i = 1$ . When,  $\Sigma F - \Sigma R$  15  $\leq -Th$ , then it is judged that  $b_i = 0$ . And, when  $-Th < \Sigma F - \Sigma R < Th$ , then it is judged that information is not embedded in the above-mentioned predetermined areas  $Q_1 - Q_m$ . This processing is carried out for every bit  $b_1 - b_n$ , so as to extract the digital watermark embedded in the image data.

20         Digital watermarking technique is described in detail in Proceedings of the 56th National Convention of IPSJ 1998, pages 3-37 - 3-38.

25         In Fig. 17, it is assumed that the origin  $O$  of the X-Y coordinates for specifying a position of each pixel constituting image data is set at the upper left vertex of the image data in question. Here, as shown in Fig. 18,

when an upper portion of image data in which digital watermark information is embedded is cut, then, respective embedded positions in the X-Y coordinates of the bits  $b_1$  -  $b_n$  constituting the digital watermark information are  
5 changed.

According to the present invention, even in such a case, it is possible to extract each bit constituting digital watermark information.

Now, a first embodiment of the present invention  
10 will be described in the following.

First, there is described a digital watermark information embedding apparatus used in a digital watermark system to which the present embodiment is applied.

Fig. 1 is a block diagram showing the digital  
15 watermark information embedding apparatus used in the digital watermark system to which the first embodiment of the present invention is applied.

As shown in the figure, the digital watermark information embedding apparatus 1 of the present embodiment  
20 comprises a processing part 100 and a storage part 110.

The processing part 100 comprises: an input-output part 101 for inputting and outputting image data, digital watermark information to be embedded in image data, and image data in which digital watermark information is  
25 embedded; a control part 102 that controls each part of the digital watermark information embedding apparatus 1 in a

unified manner; a block dividing part 103; and an information embedding part 104.

The storage part 110 comprises: an image hold part 111 that holds image data inputted through the input-output part 101; a watermark information hold part 112 that holds digital watermark information  $b_1 - b_n$  ( $2 \leq n$ ) to be embedded in the image data inputted through the input-output part 101 and held in the image hold part 111; a watermarked image hold part 113 that holds image data in which the digital watermark information  $b_1 - b_n$  is embedded; and a group array/location rule storage part 114 that stores a rule of embedding the digital watermark information  $b_1 - b_n$  in the image data.

The block dividing part 103 divides image data held in the image hold part 111 into a plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels, according to the group array/location rule stored in the group array/location rule storage part 114, as shown in Fig. 2.

The information embedding part 104 embeds the digital watermark information  $b_1 - b_n$ , which is held in the watermark information hold part 112, in the image data held in the image hold part 111, according to the group array/location rule stored in the group array/location rule storage part 114.

In detail, the digital watermark information  $b_1 - b_n$  and information p that specifies embedding format are

embedded in the image data as follows. Namely, groups G, each of which has a predetermined array, are located on the image data so as to cover all the image data. The mentioned array consists of: areas  $T_1 - T_n$  in which the 5 digital watermark information  $b_1 - b_n$  is respectively embedded; an area J in which the information p that specifies embedding format of the digital watermark information  $b_1 - b_n$  in the areas  $T_1 - T_n$  is embedded; and an area H in which information is not embedded. And, a 10 plurality of areas S obtained by division of the image data by the block dividing part 103 are each allocated to some one of the areas  $T_1 - T_n$ , J, and H, without fail.

Here, embedding of the digital watermark information  $b_1 - b_n$  and the information p in the image data is carried 15 out by increasing or decreasing brightness of the image data in the corresponding area by U, according to a value (0, 1) of a bit of the information, similarly to the conventional technique. However, in the present embodiment, as a pixel data brightness 20 increasing/decreasing direction pattern depending on a bit value of information to be embedded, two kinds of patterns are prepared in order that extraction of information embedded in a certain area S of each group G is not affected by information embedded in the areas S located on 25 the four sides of the area S in question. The information p is used for specifying this brightness

increasing/decreasing direction pattern.

Here, the pixel data brightness increasing/decreasing direction pattern applied to each group G is set as follows. Namely, for example, in the 5 case that the groups G each consisting of  $3 \times 3$  (nine in total) areas  $S_1 - S_9$ , are located to cover all the image data as shown in Fig. 3, there are prepared a first pattern in which pixel data brightness increasing/decreasing directions for a bit value are same for all the areas  $S_1 - S_9$ , within a group G, and a second pattern in which pixel 10 data brightness increasing/decreasing directions are opposite between vertically- or laterally-adjacent areas S, as shown in Fig. 4. Then, as shown in Fig. 5, the patterns are set on the image data so that mutually different 15 brightness increasing/decreasing direction patterns are applied to vertically- or laterally-adjacent groups G.

Further, allocation of the areas  $T_1 - T_n$ , J, and H to the areas S within a group G is carried out so as to satisfy the following conditions.

20 Namely, extraction of the information p, which specifies the applied brightness increasing/decreasing direction pattern, from the image data should be carried out before the brightness increasing/decreasing direction pattern applied to the group G is ascertained.

25 Accordingly, the area J in which the information p is embedded is allocated to an area S whose image data

brightness increasing/decreasing direction for a bit value is same for all the brightness increasing/decreasing direction patterns. In the example shown in Fig. 4, the area J is allocated to some one of the areas  $S_1$ ,  $S_3$ ,  $S_5$ ,  $S_7$ , 5 and  $S_9$ .

Further, with respect to the area H in which information is not embedded, in order to detect the fact that information is not embedded in this area, it is necessary that the detection is not affected by brightness 10 increasing/decreasing owing to information embedded in the areas located on the four sides of the area in question. Therefore, the area H in which information is not embedded is allocated to such an area S that, according to the employed brightness increasing/decreasing direction 15 patterns, image data brightness increasing/decreasing directions for a bit value are reversed in the areas located on the four sides of the area in question. In the example shown in Fig. 4, the area H is allocated to some one of the areas  $S_1$ ,  $S_3$ ,  $S_5$ ,  $S_7$ , and  $S_9$ .

20 The areas  $T_1$  -  $T_n$  in which the digital watermark information  $b_1$  -  $b_n$  is embedded are necessarily allocated to the other areas  $S_1$  -  $S_9$ , than the areas to which the areas J and H have been allocated. In that case, it is desirable to note the following, in order that an error is not caused 25 in the below-described detection of the area H in which information is not embedded.

Namely, in the case that the areas  $T_i$  ( $1 \leq i \leq n$ ) are allocated to areas S in which the image data brightness increasing/decreasing direction for a bit value is reversed depending on the brightness increasing/decreasing direction 5 patterns, when brightness averages  $F$  for pixel data within the area  $T_i$  are obtained respectively for the groups G and added, brightness increase or decrease owing to a bit value of watermark information  $b_i$  embedded in that area  $T_i$  may be canceled. Accordingly, their total sum  $\Sigma F$  does not reflect 10 the brightness increase or decrease owing to the information embedding.

On the other hand, image data brightness increase/decrease directions for a bit value in the adjacent areas located on the four sides of the area  $T_i$  in 15 question are same for all the brightness increasing/decreasing direction patterns. Accordingly, with respect to these adjacent areas, the total sum  $\Sigma R$  of image data brightness averages  $R$  obtained respectively for the groups G reflects the brightness increase or decrease 20 owing to the bit value of the embedded information. Thus, generally, there arises a difference to some degree between the total sum  $\Sigma F$  and the total sum  $\Sigma R$ .

However, in the case that bit values of information embedded in the adjacent areas located on the four sides of 25 the area  $T_i$  in question are 1 for two values and 0 for the remaining two areas, then, when the brightness average  $R$  of

the pixel data embedded in these adjacent areas is taken, brightness increase or decrease is cancelled. Accordingly, the difference between the total sum  $\Sigma F$  and the total sum  $\Sigma R$  becomes small, and there is the possibility that the 5 area  $T_i$  in question is erroneously detected as the area H in which information is not embedded. Thus, when the area  $T_i$  is allocated to an area S for which image data brightness increasing/decreasing direction for a bit value is reversed according to the employed brightness 10 increasing/decreasing direction patterns, the area H in which information is not embedded is allocated to one of the adjacent areas located on the four sides of the area S in question. As a result, the brightness average R of the pixel data embedded in these adjacent areas reflects the 15 brightness increase or decrease owing to a bit value of the embedded information.

In the example shown in Figs. 4 and 5, when the areas  $T_1 - T_n$ , J, and H are allocated to the areas  $S_1 - S_9$ , within a group G, for example, as shown in Fig. 6, the 20 above-described conditions are satisfied.

Next, a hardware configuration of the digital watermark information embedding apparatus to which the present embodiment is applied will be described.

Fig. 7 is a view showing an example of the hardware 25 configuration of the digital watermark information embedding apparatus 1 shown in Fig. 1.

As shown in the figure, the digital watermark information embedding apparatus of the present embodiment can be implemented on an information processing apparatus of general construction comprising a processor (CPU) 201, a 5 memory 202, an external storage unit 203 such as a hard disk unit, another external storage unit 204, an input unit 205 such as a keyboard, an output unit 206 such as a display, and an interface 207 with the external storage units and input and output units. Here, each part of the 10 processing part 100 shown in Fig. 1 is realized as a process that is substantiated on the information processing apparatus when the CPU 201 executes a program loaded onto the memory 202. Further, in this case, the memory 202 and the external storage units 203, 204 are used as the storage 15 part 110 shown in Fig. 1.

The above-mentioned program that is executed by the CPU 201 for substantiating the digital watermark information embedding apparatus of the present embodiment on the information processing apparatus is stored in the 20 external storage unit 203 in advance and loaded onto the memory 202 as the need arises, so as to be executed by the CPU 201. Or, the program may be loaded onto the memory 202 from a portable storage medium 208 such as CD-ROM through the external storage unit 204 that handles the mentioned 25 portable storage medium 208, and then, executed by the CPU 201. Or, the program may be once installed in the external

storage unit 203 from a portable storage medium 208 through the external storage unit 204, and thereafter, loaded onto the memory 202 from the external storage unit 203 as the need arises, so as to be executed by the CPU 201. Or, the 5 program may be once downloaded into the external storage unit 203 from a network through a network connecting apparatus (not shown) and loaded onto the memory 202, or directly loaded onto the memory 202 through a network, so as to be executed by the CPU 201.

10 Next, operation of the digital watermark information embedding apparatus to which the present embodiment is applied will be described.

15 Fig. 8 is a flowchart for explaining operation of the digital watermark information embedding apparatus 1 shown in Fig. 1. This flow is started when the control part 102 cooperates with the input-output part 101 to make image data and digital watermark information  $b_1 - b_n$  held in the image hold part 111 and the watermark information hold part 112, respectively.

20 First, as previously described referring to Fig. 2, the block dividing part 103 divides the image data held in the image hold part 111 into a plurality of areas S each consisting of predetermined  $M \times N$  ( $1 \leq M, N$ ) of pixels, according to the rule stored in the group array/location 25 rule storage part 114 (Step S1001).

Next, as previously described referring to Figs. 2 -

5, the information embedding part 104 establishes a brightness increasing/decreasing direction pattern (first pattern or second pattern) applied to each group G, according to the rule stored in the group array/location rule storage part 114 (Step S1002). Then, as previously described referring to Fig. 6, groups G are located one after another to cover all the image data, according to the rule stored in the group array/location rule storage part 114. Each of the groups G has a predetermined array 10 consisting of the areas  $T_1 - T_n$  in which the digital watermark information  $b_1 - b_n$  is embedded respectively, the area J in which the information p specifying brightness increasing/decreasing direction patterns is embedded; and the area H in which information is not embedded. And, the 15 areas  $T_1 - T_n$ , J, and H are allocated to a plurality of areas S obtained by division of the image data by the block dividing part 103 such that each area S is necessarily allocated with some one of the areas  $T_1 - T_n$ , J, and H (Step S1003).

20 Next, the information embedding part 104 reads one bit  $b_i$  ( $1 \leq i \leq n$ ) of the digital watermark information from the watermark information hold part 112 (Step S1004). Then, the digital watermark information  $b_i$ , which has been read, is embedded in the corresponding area  $T_i$  of each 25 group G allocated in Step S1003, by increasing or decreasing brightness of the pixel data within the area  $T_i$

in question by U depending on the bit value of the digital watermark information  $b_i$ , according to the brightness increasing/decreasing direction pattern of each group G established in Step S1002 (Step S1005).

5 Next, when the processes of the above-described Steps S1004 and S1005 are carried out for all the digital watermark information  $b_1 - b_n$  held in the watermark information hold part 112 (Step S1006), then the information embedding part 104 embeds the information p  
10 identifying the brightness increasing/decreasing direction pattern (first or second pattern) established in Step S1003 (Step S1007). Here, as described above, with respect to the embedding of the information p in the area J, the pixel data brightness increasing/decreasing direction for a bit  
15 value is same for all the brightness increasing/decreasing direction patterns.

When embedding of the information p in the area J of each group G is finished, namely, when embedding of the digital watermark information  $b_1 - b_n$  and the information p,  
20 which specifies the embedding format of the digital watermark information for each group G, in the image data are finished, then the watermarked image hold part 113 is made to hold the processed image data, to finish the present flow. The image data held in this image hold part  
25 113 is outputted as the watermarked image data through the input-output part 101, as the need arises.

Next, there will be described a digital watermark information extracting apparatus used in a digital watermark system to which the present embodiment is applied.

5 Fig. 9 is a block diagram showing the digital watermark information extracting apparatus used in the digital watermark system to which an embodiment of the present invention is applied.

As shown in the figure, the digital watermark 10 information extracting apparatus 3 of the present embodiment comprises a processing part 300 and a storage part 310.

The processing part 300 comprises: an input-output part 301 for inputting and outputting image data in which 15 digital watermark information is embedded and the digital watermark information extracted from that image data; a control part 302 for controlling each part of the digital watermark information extracting apparatus 3 in a unified manner; a block dividing part 303; a group recognizing part 20 304; and an information extracting part 305.

The storage part 310 comprises: an image hold part 311 for holding image data in which digital watermark information  $b_1 - b_n$  is embedded and which is inputted through the input-output part 301; a group array/location 25 rule storage part 312 for storing a rule of extracting the digital watermark information  $b_1 - b_n$  from the image data;

and a watermark information hold part 313 for holding the digital watermark information  $b_1 - b_n$  extracted from the image data. Here, the rule stored in the group array/location rule storage part 312 is same as the rule 5 stored in the group array/location rule storage part 114 of the digital watermark information embedding apparatus 1 shown in Fig. 1.

The block dividing part 303 divides image data embedded with the digital watermark information  $b_1 - b_n$ , 10 which is held in the image hold part 311, into a plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels in the same manner as the block dividing part 303 of the digital watermark information embedding apparatus 1 shown in Fig. 1. Here, the size ( $M \times N$ ) of the area S is set as 15 the area S established in the block dividing part 303 of the digital watermark information embedding apparatus 1 shown in Fig. 1.

The group recognizing part 304 recognizes respective locations of a plurality of groups G located on the image 20 data embedded with the digital watermark information  $b_1 - b_n$ , which is held in the image hold part 311, according to the rule stored in the group array/location rule storage part 312. In detail, this is carried out in the following manner.

25 First, temporary groups G' each having the same size and shape as the group G specified by the rule stored in

the group array/location rule storage part 312 are located on the image data divided into a plurality of areas S by the block dividing part 303, in a predetermined manner specified by the rule stored in the group array/location rule storage part 312 (namely, located so as to cover all the image data).

Next, for respective areas S of the temporary groups G' located on the image data as described above, it is examined if information is embedded or not, so as to detect the area H in which information is not embedded.

In detail, for example, the case that the temporary groups G' each having the same size and shape as the group G consisting of  $3 \times 3$  (nine in total) areas  $S_1 - S_9$ , as shown in Fig. 3 are located to cover all the image data may be considered. In that case, with respect to the area  $S_i$  ( $1 \leq i \leq 9$ ), a brightness average F for pixel data within the area  $S_i$  in question is obtained for each temporary group G', and the total sum  $\Sigma F$  of these averages is obtained. Further, a brightness average R for pixel data in the adjacent areas located on the four sides of the area  $S_i$  in question is obtained, and the total sum  $\Sigma R$  of these averages is obtained. Then, if the condition  $|\Sigma F - \Sigma R| \geq Th$  (where Th differs depending on required error rates, and, for example, it is assumed that  $Th = 1/2 \times U \times m$  ( $m$ : the number of the temporary groups G' located on the image data)) is satisfied, it is judged that some information is

embedded in the area  $S_i$  in question. On the other hand, if the condition  $|\Sigma F - \Sigma R| < Th$  is satisfied, it is judged that information is not embedded in the area  $S_i$  in question. This process is carried out for all the areas  $S_1$  -  $S_9$ , so as to detect the area in which information is not embedded.

As described above, with respect to an area  $S$  that is allocated to another area than the area  $H$  in which information is not embedded, when the image data brightness increasing/decreasing direction for a bit value is same for all the brightness increasing/decreasing direction patterns, then, the total sum  $\Sigma F$  of the pixel data brightness averages  $F$  obtained for that area respectively in the temporary groups  $G'$  reflects brightness increase or decrease owing to information embedded in the area in question. On the other hand, with respect to the total sum  $\Sigma R$  of the pixel data brightness averages  $R$  obtained for the adjacent areas located on the four sides of the area in question respectively in the temporary groups  $G'$ , image data brightness increasing/decreasing direction for bit values in these adjacent areas is reversed depending on the brightness increasing/decreasing direction patterns. Accordingly, brightness increase or decrease owing to embedded information is cancelled. As a result, there is generated a difference between the total sum  $\Sigma F$  and the total sum  $\Sigma R$  to some degree.

Further, with respect to an area S that is allocated to another area than H in which information is not embedded, when the image data brightness increasing/decreasing direction for a bit value is reversed 5 according to the employed brightness increasing/decreasing direction patterns, then, brightness increase or decrease owing to information embedded in the area S in question is cancelled in the total sum  $\Sigma F$  of the pixel data brightness averages F obtained for that area respectively in the 10 temporary groups G'. On the other hand, the total sum  $\Sigma R$  of the pixel data brightness averages R obtained for the adjacent areas located on the four sides of the area in question respectively in the temporary groups G' reflects brightness increase or decrease owing to information 15 embedded in these areas. The reason is that the image data brightness increasing/decreasing direction for bit values in these adjacent areas is same for all the brightness increasing/decreasing direction patterns, and one of these four adjacent areas is the area H in which information is 20 not embedded. Thus, the total sum  $\Sigma R$  reflects brightness increase or decrease owing to the information embedded in these three areas other than the area H. As a result, there arises a difference to some degree between the total sum  $\Sigma F$  and the total sum  $\Sigma R$ . 25 In contrast, the area H in which information is not embedded is allocated to an area S for which image data

brightness increasing/decreasing direction for bit values in the adjacent areas located on the four sides of the area in question is reversed depending on the brightness increasing/decreasing direction patterns. Accordingly,

5 brightness increase or decrease owing to embedded information is cancelled in the total sum  $\Sigma R$  of the pixel data brightness averages  $R$  obtained for the adjacent areas located on the four sides of the area in question respectively in the temporary groups  $G'$ . On the other

10 hand, since information is not embedded in the area  $H$  at all, the total sum  $\Sigma F$  of the pixel data brightness averages  $F$  obtained for the area in question respectively in the temporary groups  $G'$  does not include brightness increase or decrease owing to information embedding. As a result, a

15 difference generated between the total sum  $\Sigma F$  and the total sum  $\Sigma R$  is small.

Accordingly, it is possible to detect the area  $H$  in which the information is not embedded by obtaining the difference between the total sum  $\Sigma F$  and the total sum  $\Sigma R$  obtained for the temporary groups  $G'$  with respect to the area  $S_i$ .

Next, when the areas  $H$  in which information is not embedded are detected as described above, then a plurality of groups  $G$ , which are located on the image data and each 25 have a predetermined array specified by the rule stored in the group array/location rule storage part 312, are

recognized based on the locations of the areas H on the image data. That array consists of: the areas  $T_1 - T_n$  in which digital watermark information  $b_1 - b_n$  is embedded respectively; the area J in which the information p specifying the image data brightness increasing/decreasing direction pattern is embedded; and the area H in which information is not embedded.

Now, for example as shown in Fig. 6, it is assumed that digital watermark information  $b_1 - b_7$  is embedded in image data such that groups G are located one after another so as to cover all the image data, each group G consisting of the areas  $T_1 - T_7$ , in which digital watermark information  $b_1 - b_7$  is embedded respectively, the area J in which information p is embedded, and the area H in which information is not embedded, with those areas being allocated to  $3 \times 3$  (nine in total) areas S in a predetermined array. Then, a case of an image shift caused by cutting this image data by upper one pixel line is considered.

In this case, the temporary groups  $G'$  are allocated as shown in Fig. 10. In the present embodiment, when digital watermark information is embedded in the image data, the groups G are located one after another on the image data so as to cover all the image data, each group G consisting of the areas  $T_1 - T_7$  in which the digital watermark information  $b_1 - b_7$  is embedded respectively, the

area J in which the information p is embedded, and the area H in which digital watermark information is not embedded, these areas being allocated to  $3 \times 3$  (nine in total) areas S according to the predetermined array. Accordingly, each 5 of the temporary groups G' inevitably includes the area H in which information is not embedded.

Accordingly, by detecting the areas H in which information is not embedded from the image data, it is possible to recognize each of the groups G located on the 10 image data as shown in Fig. 11, based on the positions of the areas H in the image data.

The information extracting part 305 extracts the digital watermark information  $b_1 - b_n$  from the image data embedded with the digital watermark information  $b_1 - b_n$ , 15 which is held in the image hold part 311, based on the respective locations of the groups G recognized by the group recognizing part 304.

In detail, first, the information p is extracted from the area J in each group G recognized by the group 20 recognizing part 304, in order to find the brightness increasing/decreasing direction pattern used for embedding information in that group G. Here, in order to extract the information p from the area J, a difference  $F - R$  between an average brightness F of the pixel data within the area J 25 and an average brightness R of the pixel data in the adjacent areas located on the four sides of the area J in

question is examined. When the difference  $F - R$  is more than or equal to a predetermined threshold  $+Th$  (set to a slightly lower value than  $U$  used in embedding information), it is judged that the information  $p$  embedded in that area 5 has a bit value 1. When, the difference  $F - R$  is less than or equal to a predetermined threshold  $-Th$ , then it is judged that the information  $p$  embedded in that area has a bit value 0.

Next, when the value of the information  $p$  embedded 10 in the area  $J$  of each group  $G$  is ascertained, then, with respect to an area  $T_i$  ( $1 \leq i \leq n$ ), a difference between an average brightness  $F$  for pixel data within that area and an average brightness  $R$  for pixel data in the adjacent areas located on the four sides of the area in question is 15 extracted from each group  $G$ , taking the brightness increasing/decreasing direction pattern specified by the mentioned information  $p$  into consideration. Here, the consideration of the brightness increasing/decreasing direction pattern specified by the information  $p$  means the 20 following. Namely, when the brightness increasing/decreasing direction pattern specified by the information  $p$  of a certain group  $G$  indicates that digital watermark information  $b_i$  is embedded such that brightness for an area  $T_i$  of the group  $G$  in question is increased by  $U$  25 for a bit 1 and decreased by  $U$  for a bit 0, then,  $F - R$  is extracted as the difference between the average  $F$  and the

average R. When the brightness increasing/decreasing direction pattern indicates that the digital watermark information  $b_i$  is embedded such that the brightness is decreased by U for a bit 1 and increased by U for a bit 0.

5 then,  $R - F$  is extracted as the difference between the average F and the average R. As a result, the difference in the sign of the mentioned difference between the averages for a bit value owing to the difference in the pixel data brightness increasing/decreasing direction for a

10 bit value is cancelled.

When, with respect to an area  $T_i$ , the difference between the average brightness F of the pixel data within the area  $T_i$  and the average brightness R of the pixel data in the adjacent areas located on the four sides of the area 15 in question is extracted for each group G as described above, then, the total sum Z of the differences in question is obtained and compared with a predetermined threshold W (which is set to (a threshold Th set slightly lower than U used for embedding the information)  $\times$  (the number of the 20 groups recognized by the group recognizing part 304)) to examine the bit value of the digital watermark information  $b_i$ . For example, when the total sum Z is more than or equal to the threshold  $+W$ , then the bit value of the digital watermark information  $b_i$  is judged to be 1, and 25 when it is less than or equal to a threshold  $-W$ , then the bit value of the digital watermark information  $b_i$  is judged

to be 0.

The above process is carried out for all the areas  $T_1 - T_n$  so as to extract the digital watermark information  $b_1 - b_n$  from the image data.

5 Next, a hardware configuration of the digital watermark information extracting apparatus to which the present embodiment is applied will be described.

The hardware configuration of the digital watermark information extracting apparatus of the present embodiment  
10 is fundamentally same as the hardware configuration of the digital watermark information embedding apparatus shown in Fig. 7. Namely, it is implemented on an information processing apparatus of general construction comprising CPU 201, a memory 202, an external storage unit 203 such as a  
15 hard disk unit, another external storage unit 204, an input unit 205 such as a keyboard, an output unit 206 such as a display, and an interface 207 with the external storage units and input and output units. Here, each part of the processing part 300 shown in Fig. 9 is realized as a  
20 process that is substantiated on the information processing apparatus when the CPU 201 executes a program loaded onto the memory 202. Further, in this case, the memory 202 and the external storage units 203, 204 are used as the storage part 310 shown in Fig. 9.

25 The above-mentioned program that is executed by the CPU 201 for substantiating the digital watermark

information extracting apparatus of the present embodiment on the information processing apparatus is stored in the external storage unit 203 in advance and loaded onto the memory 202 as the need arises, so as to be executed by the 5 CPU 201. Or, the program may be loaded onto the memory 202 from a portable storage medium 208 such as CD-ROM through the external storage unit 204 that handles the mentioned portable storage medium 208, and then executed by the CPU 201. Or, the program may be once installed in the external 10 storage unit 203 from a portable storage medium 208 through the external unit 204, and thereafter, loaded onto the memory 202 from the external storage unit 203 as the need arises, so as to be executed by the CPU 201. Or, the program may be once downloaded into the external storage 15 unit 203 from a network through a network connecting apparatus (not shown) and loaded onto the memory 202, or directly loaded onto the memory 202 through a network, so as to be executed by the CPU 201.

Here, the digital watermark information embedding 20 apparatus and the digital watermark information extracting apparatus used in the digital watermark system of the present embodiment may be implemented on the same information processing apparatus.

Next, operation of the digital watermark extracting 25 apparatus to which the present embodiment is applied will be described.

Fig. 12 is a flowchart for explaining operation of the digital watermark information extracting apparatus 3 shown in Fig. 9. This flow is started when the control part 302 cooperates with the input-output part 301 to make 5 image data embedded with the digital watermark information  $b_1 - b_n$  held in the image hold part 311.

First, the block dividing part 303 divides the image data held in the image hold part 311 into a plurality of areas S each having a size set by the block dividing part 10 303 of the digital watermark information embedding apparatus 1 (Step S3001).

Next, as previously described referring to Fig. 10, the group recognizing part 304 locates the temporary groups G', each of which has the same size and shape as the group 15 G specified by the rule stored in the group array/location rule storage part 312, in the image data divided into a plurality of areas S in the Step S3001, on a predetermined manner specified by the rule stored in the group array/location rule storage part 312 (Step S3002).

20 Next, as described above, the group recognizing part 304 detects the area H in which information is not embedded for each temporary group G' located on the image data (Step S3003).

Then, as previously described referring to Fig. 11, 25 based on the locations of the detected areas H on the image data, the group recognizing part 304 recognizes a plurality

of groups G that are located on the image data and each have the predetermined array specified by the rule stored in the group array/location rule storage part 312 (Step S3004). That array consists of: the areas  $T_1 - T_n$  in which 5 digital watermark information  $b_1 - b_n$  is embedded respectively; the area J in which the information p specifying the image data brightness increasing/decreasing direction pattern is embedded; and the area H in which information is not embedded.

10 When the group recognizing part 304 finishes the recognition of the groups G, then the information extracting part 305 extracts the information p from the area J in each group G recognized by the group recognizing part 304, and examines the bit value, so as to judge the 15 brightness increasing/decreasing direction patterns used in each group G (Step S3005).

Next, the information extracting part 305 notes an area  $T_i$  out of the areas  $T_1 - T_n$  in each group G recognized by the group recognizing part 304 (Step S3006).

20 Next, with respect to a certain group G, the information extracting part 305 obtains an average brightness F of pixel data within the area  $T_i$  of that group G (Step S3007), and then, obtains an average brightness R of pixel data in the adjacent areas located on the four 25 sides of the area  $T_i$  in question (Step S3008). Then, with respect to the group G in question, a difference between

the average F and the average R is obtained according to the pixel data brightness increasing/decreasing direction that is specified by the brightness increasing/decreasing direction pattern judged in Step S3005 and that is used in 5 embedding the digital watermark information  $b_i$  in the area  $T_i$  (Step S3009). In detail, when the brightness increasing/decreasing direction pattern for the group G in question indicates that the digital watermark information  $b_i$  has been embedded in the area  $T_i$  such that the brightness 10 is increased by U for a bit 1 and decreased by U for a bit 0, then,  $F - R$  is obtained as the difference between the average F and the average R. On the other hand, when the brightness increasing/decreasing direction pattern indicates that the digital watermark information  $b_i$  has 15 been embedded in the area  $T_i$  such that the brightness is decreased by U for a bit 1 and increased by U for a bit 0, then,  $R - F$  is obtained as the difference between the average F and the average R.

Next, when the processes of Steps S3007 - S3009 have 20 been finished for all the groups G recognized by the group recognizing part 304 with respect to the area  $T_i$  noted in Step S3006 (Step S3010), then, the information extracting part 305 obtains the total sum Z of the differences obtained for all the groups G in Step S3009 with respect to 25 the area  $T_i$ , and compares this total sum Z of these differences with the predetermined threshold W (which is

set to (a threshold  $Th$  set slightly lower than  $U$  used for embedding the information)  $\times$  (the number of the groups recognized by the group recognizing part 304)) (Step S3011). When the total sum  $Z$  is more than or equal to the 5 threshold  $+W$ , then it is judged that the digital watermark information  $b_i$  embedded in the area  $T_i$  of each group  $G$  is 1 (Step S3012). When the total sum  $Z$  is less than or equal to a threshold  $-W$ , then it is judged that the bit value of the digital watermark information  $b_i$  is 0 (Step S3013).  
10 Here, when the total sum  $Z$  is less than the threshold  $+W$  and more than the threshold  $-W$ , then it means that the digital watermark information  $b_i$  that should have been embedded in the area  $T_i$  is not embedded. In that case, it is possible that processing (for example, rotation  
15 processing or scaling processing) other than image shift has been carried out on the image data in which digital watermark information  $b_1 - b_n$  has been embedded by the digital watermark information embedding apparatus 1 of the present embodiment. Accordingly, after carrying out error processing (Step S3014), the present flow is ended.  
20

When the processes of Steps S3006 - S3011 are finished for all the areas  $T_1 - T_n$  in which the digital watermark information is embedded (Step S3015), the information extracting part 304 makes the information hold 25 part 313 hold the bit values of the digital watermark information  $b_1 - b_n$ , and the present flow is ended. The

information  $b_1 - b_n$  held in this watermark information hold part 313 is outputted as the digital watermark information through the input-output part 301 as the need arises.

Hereinabove, the first embodiment of the present  
5 invention has been described.

According to the present embodiment, groups G each having a predetermined array consisting of areas  $T_1 - T_n$  in which digital watermark information  $b_1 - b_n$  is respectively embedded, an area J in which information p specifying an  
10 embedding format is embedded, and an area H in which information is not embedded, are located one after another to cover all the image data, and a plurality of areas S obtained by division of the image data are each allocated to some one of the areas  $T_1 - T_n$ , J, and H, so that the  
15 digital watermark information  $b_1 - b_n$  and the information p are embedded in the image data.

Accordingly, even when image shifting processing is carried out on image data in which digital watermark information  $b_1 - b_n$  is embedded as described above, and, as  
20 a result, X-Y coordinate locations of the area  $T_1 - T_n$  in which the digital watermark information  $b_1 - b_n$  is embedded are changed, it is possible to recognize each of the groups G located on the image data in question, as follows.

Namely, by dividing the image data, on which the image  
25 shifting processing has been carried out, into a plurality of areas S, and by detecting the areas H, in which

information is not embedded, out of these areas S, it is possible to recognize each of the groups G located on the image data in question, based on the X-Y coordinates of the detected areas H in the image data.

5           Particularly, in the present embodiment, temporary groups G' (each having the same shape and size as the group G used in embedding the digital watermark information) are located on the image data (in which the digital watermark information  $b_1 - b_n$  has been embedded) according to the  
10          location rule employed for those groups G in embedding the digital watermark information. Next, by examining the areas S for each of the groups G' located one after another on the image data as described, the area H in which information is not embedded is detected. Then, each of the  
15          groups G located on the image data in question is recognized based on the X-Y coordinate value of the detected area H in the image data, and thereby, the areas  $T_1 - T_n$  in which the digital watermark information  $b_1 - b_n$  has been embedded are detected on the image data.

20          Namely, according to the present embodiment, in specifying the detected positions of the areas  $T_1 - T_n$  on the image data in which the digital watermark information  $b_1 - b_n$  is embedded, it is sufficient to calculate a difference  $|\Sigma F - \Sigma R|$ , a number of times corresponding to  
25          the number of the areas S contained in each temporary group G' so as to examine if information is embedded or not. As

a result, determination of the detected locations of the areas  $T_1$  -  $T_n$  on the image data in which the digital watermark information  $b_1$  -  $b_n$  is embedded can be carried out at high speed. This effect is particularly remarkable in

5 the case that, when processing (for example, rotation processing and scaling processing) other than image shift is carried out on the image data in which digital watermark information  $b_1$  -  $b_n$  has been embedded, the digital watermark extracting apparatus is so constructed that it can specify

10 the detected locations of the areas  $T_1$  -  $T_n$  on the image data taking such processing into consideration.

The present inventors already invented and filed an application for a patent (Japanese Patent Application No. 10-343119, US serial number 09/388,447 filed on September 15 2, 1999) on a method of extracting digital watermark information  $b_1$  -  $b_n$  from the image data that has been subjected to reversible geometric transformation (transformation for which the original image data before the transformation can be recovered) after the digital watermark information  $b_1$  -  $b_n$  was embedded. This method is carried out by repeating a process of investigating embedded locations in the X-Y coordinates (determined in advance with a person who embeds the information in the image data) in the image data for each of the digital watermark information  $b_1$  -  $b_n$  while carrying out the same transformation processing on the image data as the left-

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right reversal, scaling processing, and rotation processing that might have been carried out on the image data in question, until the corresponding digital watermark information  $b_1 - b_n$  is detected from all the embedded 5 locations.

This method can be applied to the image shift processing. Namely, by repeating a process of changing the origin of the image data in the X-Y coordinates while carrying out the process in combination with the above-10 mentioned transformation processing, it is also possible to extract the digital watermark information  $b_1 - b_n$  from the image data on which the reversible geometric transformation and image shift processing have been carried out after embedding of the digital watermark information  $b_1 - b_n$ . 15 However, in that case, the number of times of search for specifying the detected location of each of the digital watermark information  $b_1 - b_n$  increases extremely and a burden on the processing increases rapidly.

Figs. 13A and 13B show flowcharts for explaining the 20 difference in processing burdens between the cases of Figs. 13A and 13B. In the case of Fig. 13A, the method of repeating the same transformation processing as the left-right reversal, scaling processing, and rotation processing that might have been carried out on the image data until 25 the digital watermark information  $b_1 - b_n$  is extracted is applied to the transformation by image shift processing.

In the case of Fig. 13B, the mentioned method is combined with the extract method of the present embodiment.

In Fig. 13A, when rotating processing (S5002) on the image data is carried out up to 360 degrees, increasing by 5 1 degree, and scaling processing (S5003) is carried out in the range of the magnification ratio of 0.5 - 2.0 at intervals of 0.1, then the number of search for extracting the digital watermark information  $b_1 - b_n$  required for combination of left-right reversal (S5001), rotating 10 processing (S5002), and scaling processing (S5003) becomes  $2$  (for left-right reversal)  $\times$  360 (for rotation processing)  $\times$  21 (for scaling processing) = 15,120, at most. When, image shift processing (S5004) is carried out in addition, the number of search increases rapidly. Namely, the number 15 of pixels constituting the image data is enormous, and the location of the origin O in the X-Y coordinates required for specifying each pixel data is not always located on the image data (for example, as shown in Fig. 18, it is possible that, when a part of the image data is cut, the 20 origin O in the original data before the cut is located in the cut part). As a result the number of search for the location of the origin O in the X-Y coordinates becomes enormous. The above-mentioned number of search 15,120 is multiplied by this number, and thus the number of times for 25 carrying out the routine (S5006 - S5009) of the flow becomes enormous.

On the other hand, as shown in Fig. 13B, according to the case to which the present embodiment is applied, the number of time for carrying out the routine of the flow is not fundamentally changed from the case in which the 5 countermeasure for the image shift processing is not taken. Here is employed S5014 (the flow of Fig. 11) instead of the routine (S5004, S5006) of Fig. 13A.

As described above, the present embodiment is particularly effective for the case that, when geometric 10 transformation processing other than image shift is carried out on image data in which digital watermark information  $b_1 - b_n$  is embedded, the digital watermark extracting apparatus is constructed such that detected location of the areas  $T_1 - T_n$  on the image data can be specified taking such 15 processing into consideration.

Further, the above embodiment has been described with respect to the case that, when digital watermark information is embedded in image data, one area H in which information is not embedded is allocated in each group G. 20 However, a plurality of areas H in which information is not embedded may be allocated in each group G. In that case, as shown in Fig. 14, when those areas H are allocated asymmetrically in the vertical and horizontal directions in each group G, then, by investigating the arrangement of 25 those areas H in extracting the information, it is possible to detect left-right reversal carried out on the image data

as shown in Fig. 15 and rotation carried out on the image data as shown in Fig. 16, at the same time.

Further, instead of a plurality of areas H in which information is not embedded and which are asymmetric in the 5 vertical and horizontal directions as shown in Fig. 14, areas each embedded with a bit value 1 may be allocated, for example. In that case, by detecting the areas having the bit value 1 and arranged in that way, locations of the groups G on the image data can be specified.

10        Further, in the present embodiment, as the brightness increasing/decreasing direction patterns applied to each group G in embedding digital watermark information in image data, the case in which the two patterns as shown in Fig. 4 are employed has been described. However, three 15 or more patterns may be used. In that case, information  $p_1 - p_k$  (k depends on the number of the patterns) specifying those three or more patterns may be allocated in the areas of each group G. Further, any combination of patterns may be employed as long as the difference between the total sum 20  $\Sigma F$  of the pixel data brightness averages F with respect to the area H in which information is not embedded for every groups G and the total sum  $\Sigma R$  of the pixel data brightness average R with respect to the adjacent areas located on the four sides of the area in question for every group G is not 25 affected by increase or decrease of brightness owing to the information embedded in these adjacent areas. Further,

when the area H in which information is not embedded can be detected in some way without being affected by information embedded in those adjacent areas located on the four sides of the area H in question, then one kind of pattern may be 5 used. In that case, the area J in which the information p is embedded becomes unnecessary. Further, in that case, extraction of digital watermark information from image data is carried out as follows. Namely, for example, with respect to an area  $T_i$  ( $1 \leq i \leq n$ ) adjacent to the area H in 10 which information is not embedded, a difference  $F - R$  between an average brightness  $F$  for pixel data in the area in question and an average brightness  $R$  for pixel data in the area H in which information is not embedded is obtained for each group G. Then, the total sum  $\Sigma(F - R)$  of the 15 obtained differences  $F - R$  is compared with a threshold, in order to judge the bit value of the information embedded in the mentioned area  $T_i$ . Next, with respect to an area  $T_j$  ( $1 \leq j \leq, j \neq i$ ) adjacent to the area  $T_i$  whose bit value of the embedded information has been judged, a difference  $F - R'$  20 between an average brightness  $F$  for pixel data in the area  $T_j$  in question and a value  $R'$  obtained by subtracting the brightness increase or decrease according to the bit value of the information embedded in the area  $T_i$  from the average brightness  $R$  for the pixel data in the area  $T_i$  is obtained 25 for each group G. Then, the total sum  $\Sigma(F - R')$  of the obtained differences  $F - R'$  is compared with a threshold in

order to judge the bit value of the information embedded in the mentioned area  $T_j$ . When the digital watermark information  $b_1 - b_n$  is extracted from the image data by carrying out this process for all the areas  $T_1 - T_n$  in which 5 the digital watermark information  $b_1 - b_n$  is embedded, then the bit value of the information embedded in the area  $T_i$  can be judged with accuracy without being affected by the information embedded in the areas adjacent to the area  $T_i$ .

Further, in the present embodiment, information is 10 embedded in an area by increasing or decreasing brightness of the pixel data in that area. However, instead of brightness, another data value may be changed in order to embed information in the area in question.

Further, in the present embodiment, a static image 15 data is taken as an example of an object in which digital watermark information is embedded. Of course, however, the present invention can be applied to a dynamic image. In that case, digital watermark information may be embedded for each frame or field image data as a unit. Further, 20 when a dynamic image has been subjected to inter-frame or inter-field predictive coding, such as MPEG, then the digital watermark information may be embedded in an I-frame.

Further, digital watermark information embedded in 25 image data according to the present embodiment may be used as a watermark for calibration in detecting rotation or

scaling carried out on the image data in question.

Namely, after the digital watermark information is embedded in image data as in the present embodiment, digital watermark information on, for example, copyright is 5 embedded in the image data by another method (for example, in the method described above as the conventional technique, by changing color information instead of brightness increasing or decreasing in embedding information).

10        Then, for extracting the digital watermark information such as copyright from the image data, first a difference in brightness from the adjacent pixel data is investigated for each pixel data constituting the image data, in order to detect the areas in which information is 15 not embedded. Next, reversal processing and rotation processing are carried out so that the size and arrangement pattern of the detected areas become same as the size of the area S and the arrangement pattern of the areas in which information is not embedded, the pattern being 20 specified by the area allocation pattern within each group G and the arrangement pattern of the groups G on the image data, when the digital watermark information was embedded in the image data as in the above-described embodiment. This operation recovers the image data when the digital 25 watermark information was embedded. By previously knowing the relative positions of the locations at which the

digital watermark information such as copyright is embedded from the above-mentioned area in which information is not embedded, the information in question on copyright etc. can be extracted from the image data.

5       As described above, according to the present invention, even when the image shift is carried out on image data in which digital watermark information is embedded, the locations in which digital watermark information is embedded can be specified from the image  
10 data in question on which the image shift is carried out.

While the present invention has been described in detail and pictorially in the accompanying drawings, it is not limited to such details, since many changes and modifications recognizable to those of ordinary skill in  
15 the art may be made to the invention without departing from the spirit and the scope of thereof.

WHAT IS CLAIMED IS:

1 1. A method of embedding digital watermark information  
2  $b_1 - b_n$  ( $2 \leq n$ ) in image data, comprising steps of:  
3 dividing the image data into a plurality of areas S  
4 each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
5 defining a plurality of areas G each consisting of  $P$   
6  $\times Q$  ( $1 \leq P, Q$ ) of the areas S;  
7 allocating each of the areas S constituting each  
8 area G to some one of: areas  $T_1 - T_n$  in which said digital  
9 watermark information  $b_1 - b_n$  is respectively embedded and  
10 areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is not embedded;  
11 locating one or more areas T and one or more areas H  
12 in a predetermined arrangement in each area G; and  
13 locating the plurality of areas G in a predetermined  
14 rule.

1 2. A method of embedding digital watermark information  
2  $b_1 - b_n$  ( $2 \leq n$ ) in image data, comprising steps of:  
3 dividing the image data into a plurality of areas S  
4 each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
5 defining a plurality of areas G each consisting of  $P$   
6  $\times Q$  ( $1 \leq P, Q$ ) of the areas S;  
7 allocating each of the areas S constituting each  
8 area G to some one of: areas  $T_1 - T_n$  in which said digital  
9 watermark information  $b_1 - b_n$  is respectively embedded,

10 areas  $J_1 - J_k$  ( $1 \leq k$ ) in which information  $p_1 - p_k$  ( $1 \leq k$ )  
11 specifying an embedding format for embedding said digital  
12 watermark information  $b_1 - b_n$  in said areas  $T_1 - T_n$ , and  
13 areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is not embedded;  
14 locating one or more areas  $T$ , one or more areas  $J$ ,  
15 one or more areas  $H$  in a predetermined arrangement in each  
16 area  $G$ ; and  
17 locating the plurality of areas  $G$  in a predetermined  
18 rule.

1 3. The method of embedding digital watermark  
2 information according to Claim 2, wherein:  
3 said digital watermark information  $b_1 - b_n$  is  
4 embedded by increasing or decreasing pixel data values in  
5 the corresponding areas  $T_1 - T_n$  according to a bit value (0,  
6 1) of each bit of the digital watermark information  $b_1 - b_n$ ;  
7 and  
8 said information  $p_1 - p_k$  specifying said embedding  
9 format is embedded such that said information indicates a  
10 pattern of respective increasing/decreasing directions in  
11 the area  $T_1 - T_n$  for a bit value of the digital watermark  
12 information, in each area  $G$  to which the areas  $J_1 - J_k$   
13 embedded with said information  $p_1 - p_k$  belong.

1 4. The method of embedding digital watermark  
2 information according to Claim 1, wherein:

3           each of said areas G includes a plurality of said  
4   areas H that have been allocated so as to be asymmetric in  
5   vertical and horizontal directions in the area G in  
6   question.

1   5.       A method of extracting digital watermark  
2   information, for extracting the digital watermark  
3   information  $b_1 - b_n$  ( $2 \leq n$ ) from image data in which said  
4   digital watermark information is embedded, comprising steps  
5   of:

6           dividing the image data into a plurality of areas S  
7   each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
8           detecting areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information  
9   is not embedded, from said plurality of areas S; and  
10          recognizing a plurality of areas G each consisting  
11   of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S, said plurality of areas  
12   G being located on said image data, and said recognition  
13   being carried out based on locations of said detected areas  
14    $H_1 - H_m$  ( $1 \leq m$ ) on said image data.

1   6.       A method of extracting digital watermark  
2   information, for extracting the digital watermark  
3   information  $b_1 - b_n$  ( $2 \leq n$ ) from image data in which said  
4   digital watermark information is embedded, comprising steps  
5   of:  
6           dividing the image data into a plurality of areas S

7 each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;

8 detecting areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information

9 is not embedded, from said plurality of areas S;

10 recognizing a plurality of areas G each consisting

11 of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S, said plurality of areas

12 G being located on said image data, and said recognition

13 being carried out based on locations of said detected areas

14  $H_1 - H_m$  ( $1 \leq m$ ) on said image data;

15 in each of the plurality of areas G recognized,

16 extracting information  $p_1 - p_k$  ( $1 \leq k$ ) from areas  $J_1 - J_k$  in

17 which said information  $p_1 - p_k$  ( $1 \leq k$ ) should be embedded,

18 said information  $p_1 - p_k$  specifying an embedding format for

19 embedding said digital watermark information  $b_1 - b_n$

20 respectively in said areas  $T_1 - T_n$ ;

21 recognizing the embedding format of the digital

22 watermark information  $b_1 - b_n$  in the areas  $T_1 - T_n$  in the

23 area G in question; and

24 extracting the digital watermark information  $b_1 - b_n$

25 from the areas  $T_1 - T_n$ , according to the recognized

26 embedding format.

1 7. The method of extracting digital watermark

2 information according to Claim 6, wherein:

3 for each of the plurality of groups G recognized,

4 the information  $p_1 - p_k$  embedded in the areas  $J_1 - J_k$  is

5 extracted to recognize a pattern of increasing/decreasing

6 directions of pixel data values for a bit value of the  
7 digital watermark information, in the area G in question;  
8 and

9 each bit value of the digital watermark information  
10  $b_1 - b_n$  embedded in the areas  $T_1 - T_n$  is detected according  
11 to the recognized pattern of increasing/decreasing  
12 directions.

1 8. The method of extracting digital watermark  
2 information according to Claim 5, wherein:

3 a plurality of areas H are detected from each of the  
4 areas G;

5 the detected areas H are compared with an embedding  
6 pattern for the areas H, said embedding pattern being  
7 determined in advance such that the areas H become  
8 asymmetric in vertical and horizontal directions in the  
9 area G in question; and

10 contents of image processing carried out on the  
11 image data are judged.

1 9. A program product for making a computer execute a  
2 method of embedding digital watermark information  $b_1 - b_n$  ( $2$   
3  $\leq n$ ) in image data, comprising:

4 codes for dividing the image data into a plurality  
5 of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
6 codes for defining a plurality of areas G each

7 consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S;  
8 codes for allocating each of the area S constituting  
9 each area G to some one of: areas  $T_1 - T_n$  in which said  
10 digital watermark information  $b_1 - b_n$  is respectively  
11 embedded and areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is  
12 not embedded;  
13 codes for locating one or more areas T and one or  
14 more areas H in a predetermined arrangement in each area G;  
15 codes for locating the plurality of areas G in a  
16 predetermined rule; and  
17 a computer readable storage medium for holding the  
18 codes.

1 10. A program product for making a computer execute a  
2 method of embedding digital watermark information  $b_1 - b_n$  ( $2$   
3  $\leq n$ ) in image data, comprising:  
4 codes for dividing the image data into a plurality  
5 of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
6 codes for defining a plurality of areas G each  
7 consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S;  
8 codes for allocating each of the areas S  
9 constituting each area G to some one of: areas  $T_1 - T_n$  in  
10 which said digital watermark information  $b_1 - b_n$  is  
11 respectively embedded, areas  $J_1 - J_k$  ( $1 \leq k$ ) in which  
12 information  $p_1 - p_k$  ( $1 \leq k$ ) specifying an embedding format  
13 for embedding said digital watermark information  $b_1 - b_n$  in

14 said areas  $T_1 - T_n$ , and areas  $H_1 - H_m$  ( $1 \leq m$ ) in which  
15 information is not embedded;  
16 codes for locating one or more areas  $T$ , one or more  
17 areas  $J$ , and one or more areas  $H$  in a predetermined  
18 arrangement in each area  $G$ ;  
19 codes for locating the plurality of areas  $G$  in a  
20 predetermined rule; and  
21 a computer readable storage medium for holding the  
22 codes.

1 11. The program product according to Claim 10, further  
2 comprising:  
3 codes for embedding said digital watermark  
4 information  $b_1 - b_n$  by increasing or decreasing pixel data  
5 values in the corresponding areas  $T_1 - T_n$  according to a bit  
6 value (0, 1) of each bit of the digital watermark  
7 information  $b_1 - b_n$ ; and  
8 codes for embedding said information  $p_1 - p_k$   
9 specifying said embedding format such that said information  
10 indicates a pattern of respective increasing/decreasing  
11 directions in the areas  $T_1 - T_n$  for a bit value of the  
12 digital watermark information, in each area  $G$  to which the  
13 areas  $J_1 - J_k$  embedded with said information  $p_1 - p_k$  belong.

1 12. The program product according to Claim 9, wherein:  
2 each of said areas  $G$  includes a plurality of said

3 areas H that have been allocated so as to be asymmetric in  
4 vertical and horizontal directions in the area G in  
5 question.

1 13. A program product for making a computer execute a  
2 method of extracting digital watermark information  $b_1 - b_n$   
3 ( $2 \leq n$ ) from image data in which said digital watermark  
4 information is embedded, comprising:

5 codes for dividing the image data into a plurality  
6 of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
7 codes for detecting areas  $H_1 - H_m$  ( $1 \leq m$ ) in which  
8 information is not embedded, from said plurality of areas  
9 S;

10 codes for recognizing a plurality of areas G each  
11 consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S, said  
12 plurality of areas G being located on said image data, and  
13 said recognition being carried out based on locations of  
14 said detected areas  $H_1 - H_m$  ( $1 \leq m$ ) on said image data; and  
15 a computer readable storage medium for holding the  
16 codes.

1 14. A program product for making a computer execute a  
2 method of extracting digital watermark information  $b_1 - b_n$   
3 ( $2 \leq n$ ) from image data in which said digital watermark  
4 information is embedded, comprising:  
5 codes for dividing the image data into a plurality

6 of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;

7 codes for detecting areas  $H_1 - H_m$  ( $1 \leq m$ ) in which

8 information is not embedded, from said plurality of areas

9 S;

10 codes for recognizing a plurality of areas G each

11 consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S, said

12 plurality of areas G being located on said image data, and

13 said recognition being carried out based on locations of

14 said detected areas  $H_1 - H_m$  ( $1 \leq m$ ) on said image data;

15 codes for extracting, in each of the plurality of

16 areas G recognized, information  $p_1 - p_k$  ( $1 \leq k$ ) from areas

17  $J_1 - J_k$  in which said information  $p_1 - p_k$  ( $1 \leq k$ ) should be

18 embedded, said information  $p_1 - p_k$  specifying an embedding

19 format for embedding said digital watermark information  $b_1$

20 -  $b_n$  respectively in said areas  $T_1 - T_n$ ;

21 codes for recognizing the embedding format of the

22 digital watermark information  $b_1 - b_n$  in the areas  $T_1 - T_n$

23 in the area G in question;

24 codes for extracting the digital watermark

25 information  $b_1 - b_n$  from the areas  $T_1 - T_n$ , according to the

26 recognized embedding format; and

27 a computer readable storage medium for holding the

28 codes.

1 15. The program product according to Claim 14, further

2 comprising:

3           codes for extracting, for each of the plurality of  
4  groups G recognized, the information  $p_1 - p_k$  embedded in the  
5  areas  $J_1 - J_k$ , to recognize a pattern of  
6  increasing/decreasing directions of pixel data values for a  
7  bit value of the digital watermark information, in the area  
8  G in question, and to detect each bit value of the digital  
9  watermark information  $b_1 - b_n$  embedded in the areas  $T_1 - T_n$   
10 according to the recognized pattern of  
11 increasing/decreasing directions.

1 16.       The program product according to Claim 13, further  
2 comprising:

3           codes for detecting a plurality of areas H from each  
4  of the areas G;

5           codes for comparing the detected areas H with an  
6  embedding pattern for the areas H, said embedding pattern  
7  being determined in advance such that the areas H become  
8  asymmetric in vertical and horizontal directions in the  
9  area G in question; and

10          codes for judging contents of image processing  
11 carried out on the image data.

1 17.       An apparatus for embedding digital watermark  
2 information  $b_1 - b_n$  ( $2 \leq n$ ) in image data, comprising:

3           a processing part for dividing the image data into a  
4  plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ )

5 pixels;

6 a processing part for defining a plurality of areas

7 G each consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S;

8 a processing part for allocating each of the areas S

9 constituting each area G to some one of: areas  $T_1 - T_n$  in

10 which said digital watermark information  $b_1 - b_n$  is

11 respectively embedded and areas  $H_1 - H_m$  ( $1 \leq m$ ) in which

12 information is not embedded;

13 a processing part for locating one or more areas T

14 and one or more areas H in a predetermined arrangement in

15 each area G; and

16 a processing part for locating the plurality of

17 areas G in a predetermined rule.

1 18. An apparatus for embedding digital watermark

2 information  $b_1 - b_n$  ( $2 \leq n$ ) in image data, comprising:

3 a processing part for dividing the image data into a

4 plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ )

5 pixels;

6 a processing part for defining a plurality of areas

7 G each consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S;

8 a processing part for allocating each of the areas S

9 constituting each area G to some one of: areas  $T_1 - T_n$  in

10 which said digital watermark information  $b_1 - b_n$  is

11 respectively embedded, areas  $J_1 - J_k$  ( $1 \leq k$ ) in which

12 information  $p_1 - p_k$  ( $1 \leq k$ ) specifying an embedding format

13 for embedding said digital watermark information  $b_1 - b_n$  in  
14 said areas  $T_1 - T_n$ , and areas  $H_1 - H_m$  ( $1 \leq m$ ) in which  
15 information is not embedded;

16 a processing part for locating one or more areas  $T$ ,  
17 one or more areas  $J$ , and one or more areas  $H$  in a  
18 predetermined arrangement in each area  $G$ ; and

19 a processing part for locating the plurality of  
20 areas  $G$  in a predetermined rule.

1 19. The apparatus for embedding digital watermark  
2 information according to Claim 18, further comprising:

3 a processing part for embedding said digital  
4 watermark information  $b_1 - b_n$  by increasing or decreasing  
5 pixel data values in the corresponding areas  $T_1 - T_n$   
6 according to a bit value (0, 1) of each bit of the digital  
7 watermark information  $b_1 - b_n$ ; and

8 a processing part for embedding said information  $p_1$   
9 -  $p_k$  specifying said embedding format such that said  
10 information indicates a pattern of respective  
11 increasing/decreasing directions in the area  $T_1 - T_n$  for a  
12 bit value of the digital watermark information, in each  
13 area  $G$  to which the areas  $J_1 - J_k$  embedded with said  
14 information  $p_1 - p_k$  belong.

1 20. The apparatus for embedding digital watermark  
2 information according to Claim 17, wherein:

3           each of said areas G includes a plurality of said  
4   areas H that have been allocated so as to be asymmetric in  
5   vertical and horizontal directions in the area G in  
6   question.

1   21.    An apparatus for extracting digital watermark  
2   information  $b_1 - b_n$  ( $2 \leq n$ ) from image data in which said  
3   digital watermark information is embedded, comprising:  
4           a processing part for dividing the image data into a  
5   plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ )  
6   pixels;  
7           a processing part for detecting areas  $H_1 - H_m$  ( $1 \leq$   
8    $m$ ) in which information is not embedded, from said  
9   plurality of areas S; and  
10          a processing part for recognizing a plurality of  
11   areas G each consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S,  
12   said plurality of areas G being located on said image data,  
13   and said recognition being carried out based on locations  
14   of said detected areas  $H_1 - H_m$  ( $1 \leq m$ ) on said image data.

1   22.    An apparatus for extracting digital watermark  
2   information  $b_1 - b_n$  ( $2 \leq n$ ) from image data in which said  
3   digital watermark information is embedded, comprising: 12  
4           a processing part dividing the image data into a  
5   plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ )  
6   pixels;

7           a processing part for detecting areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is not embedded, from said  
8           plurality of areas S;

10          a processing part for recognizing a plurality of areas G each consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S, said plurality of areas G being located on said image data, and said recognition being carried out based on locations of said detected areas  $H_1 - H_m$  ( $1 \leq m$ ) on said image data;

15          a processing part for extracting, in each of the plurality of areas G recognized, information  $p_1 - p_k$  ( $1 \leq k$ ) from areas  $J_1 - J_k$  in which said information  $p_1 - p_k$  ( $1 \leq k$ ) should be embedded, said information  $p_1 - p_k$  specifying an embedding format for embedding said digital watermark information  $b_1 - b_n$  respectively in said areas  $T_1 - T_n$ ;

21          a processing part for recognizing the embedding format of the digital watermark information  $b_1 - b_n$  in the areas  $T_1 - T_n$  in the area G in question; and

24          a processing part for extracting the digital watermark information  $b_1 - b_n$  from the areas  $T_1 - T_n$ , according to the recognized embedding format.

1   23.    The apparatus for extracting digital watermark  
2   information according to Claim 22, further comprising:  
3           a processing part for extracting, for each of the plurality of groups G recognized, the information  $p_1 - p_k$  embedded in the areas  $J_1 - J_k$ , to recognize a pattern of

6 increasing/decreasing directions of pixel data values for a  
7 bit value of the digital watermark information, in the area  
8 G in question, and to detect each bit value of the digital  
9 watermark information  $b_1 - b_n$  embedded in the areas  $T_1 - T_n$   
10 according to the recognized pattern of  
11 increasing/decreasing directions.

1 24. The apparatus for extracting digital watermark  
2 information according to Claim 21, further comprising:  
3 a processing part for detecting a plurality of areas  
4 H from each of the areas G; and  
5 a processing part for comparing the detected areas H  
6 with an embedding pattern for the areas H, said embedding  
7 pattern being determined in advance such that the areas H  
8 become asymmetric in vertical and horizontal directions in  
9 the area G in question; and  
10 a processing part for judging contents of image  
11 processing carried out on the image data.

1 25. An apparatus for embedding digital watermark  
2 information  $b_1 - b_n$  ( $2 \leq n$ ) in image data, comprising:  
3 a processor; and  
4 a storage unit for storing codes for making the  
5 processor execute a method of embedding the digital  
6 watermark information; wherein:  
7 said codes comprises:

8           codes for dividing the image data into a plurality  
9 of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
10          codes for defining a plurality of areas G each  
11 consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S;  
12          codes for allocating each of the areas S  
13 constituting each area G to some one of: areas  $T_1 - T_n$  in  
14 which said digital watermark information  $b_1 - b_n$  is  
15 respectively embedded, areas  $J_1 - J_k$  ( $1 \leq k$ ) in which  
16 information  $p_1 - p_k$  ( $1 \leq k$ ) specifying a embedding format  
17 for embedding said digital watermark information  $b_1 - b_n$  in  
18 said areas  $T_1 - T_n$ , and areas  $H_1 - H_m$  ( $1 \leq m$ ) in which  
19 information is not embedded;  
20          codes for locating one or more areas T, one or more  
21 areas J, and one or more areas H in a predetermined  
22 arrangement in each area G; and  
23          codes for locating the plurality of areas G in a  
24 predetermined rule.

1 26.       An apparatus for extracting digital watermark  
2 information  $b_1 - b_n$  ( $2 \leq n$ ) from image data in which said  
3 digital watermark information is embedded, comprising:  
4           a processor; and  
5           a storage unit for storing codes for making the  
6 processor execute a method of extracting the digital  
7 watermark information; wherein:  
8           said codes comprises:

9           codes for dividing the image data into a plurality  
10    of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels;  
11           codes for detecting areas  $H_1 - H_m$  ( $1 \leq m$ ) in which  
12    information is not embedded, from said plurality of areas  
13    S;  
14           codes for recognizing a plurality of areas G each  
15    consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S, said  
16    plurality of areas G being located on said image data, and  
17    said recognition being carried out based on locations of  
18    said detected areas  $H_1 - H_m$  ( $1 \leq m$ ) on said image data; and  
19           codes for extracting, in each of the plurality of  
20    areas G recognized, information  $p_1 - p_k$  ( $1 \leq k$ ) from areas  
21     $J_1 - J_k$  in which said information  $p_1 - p_k$  ( $1 \leq k$ ) should be  
22    embedded, said information  $p_1 - p_k$  specifying an embedding  
23    format for embedding said digital watermark information  $b_1$   
24    -  $b_n$  respectively in said areas  $T_1 - T_n$ .

25

ABSTRACT OF THE DISCLOSURE

A method of embedding digital watermark information  $b_1 - b_n$  ( $2 \leq n$ ) in image data. The image data is divided into a plurality of areas S each consisting of  $M \times N$  ( $1 \leq M, N$ ) pixels. A plurality of areas G each consisting of  $P \times Q$  ( $1 \leq P, Q$ ) of the areas S are defined. Each of the areas S constituting each area G is allocated to some one of: areas  $T_1 - T_n$  in which said digital watermark information  $b_1 - b_n$  is respectively embedded and areas  $H_1 - H_m$  ( $1 \leq m$ ) in which information is not embedded. One or more areas T and one or more areas H are located in a predetermined arrangement in each area G. And, the plurality of areas G are located in a predetermined rule.

FIG. 1

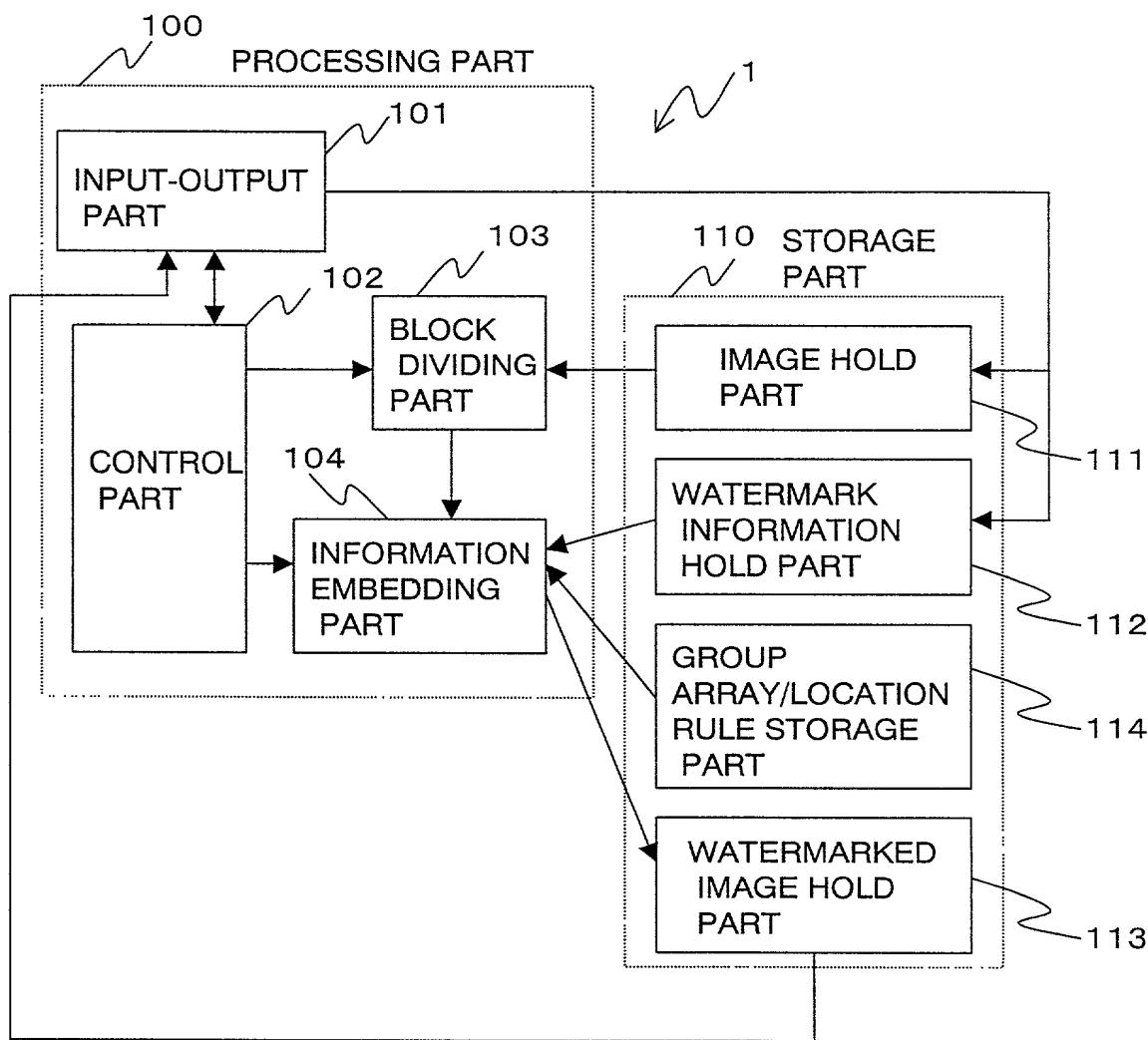


FIG.2

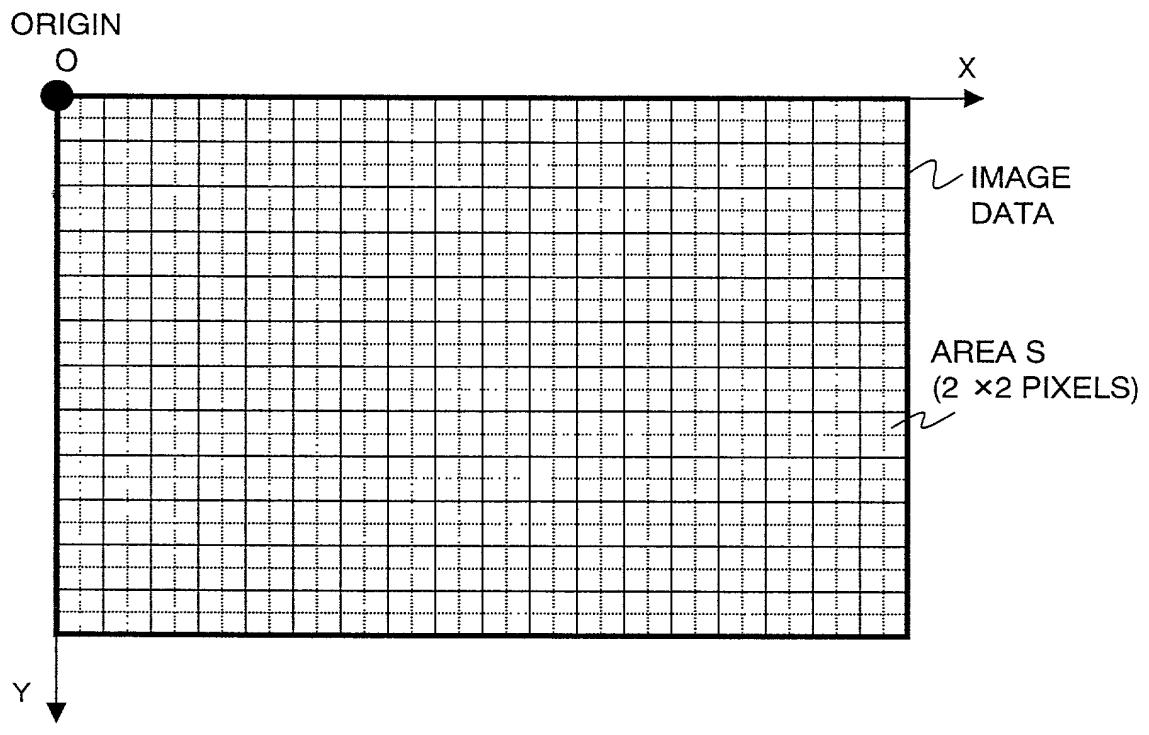


FIG.3

## ORIGIN

8

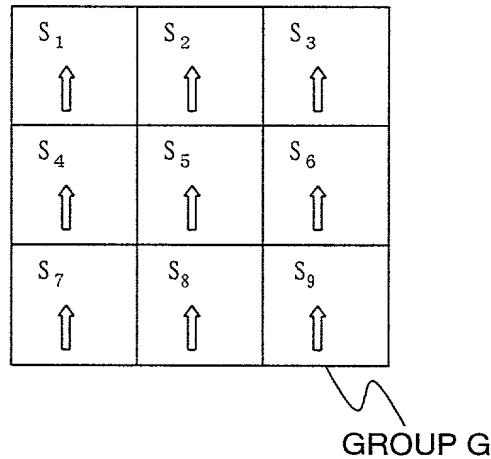
X

## IMAGE DATA

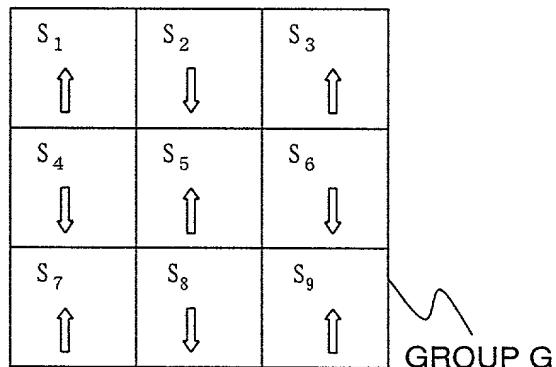
Y

FIG.4

FIRST PATTERN



SECOND PATTERN



↑ FOR A BIT 1, BRIGHTNESS IS INCREASED.  
 ↓ FOR A BIT 0, BRIGHTNESS IS DECREASED

↓ FOR A BIT 1, BRIGHTNESS IS DECREASED.  
 ↑ FOR A BIT 0, BRIGHTNESS IS INCREASED.

FIG.5

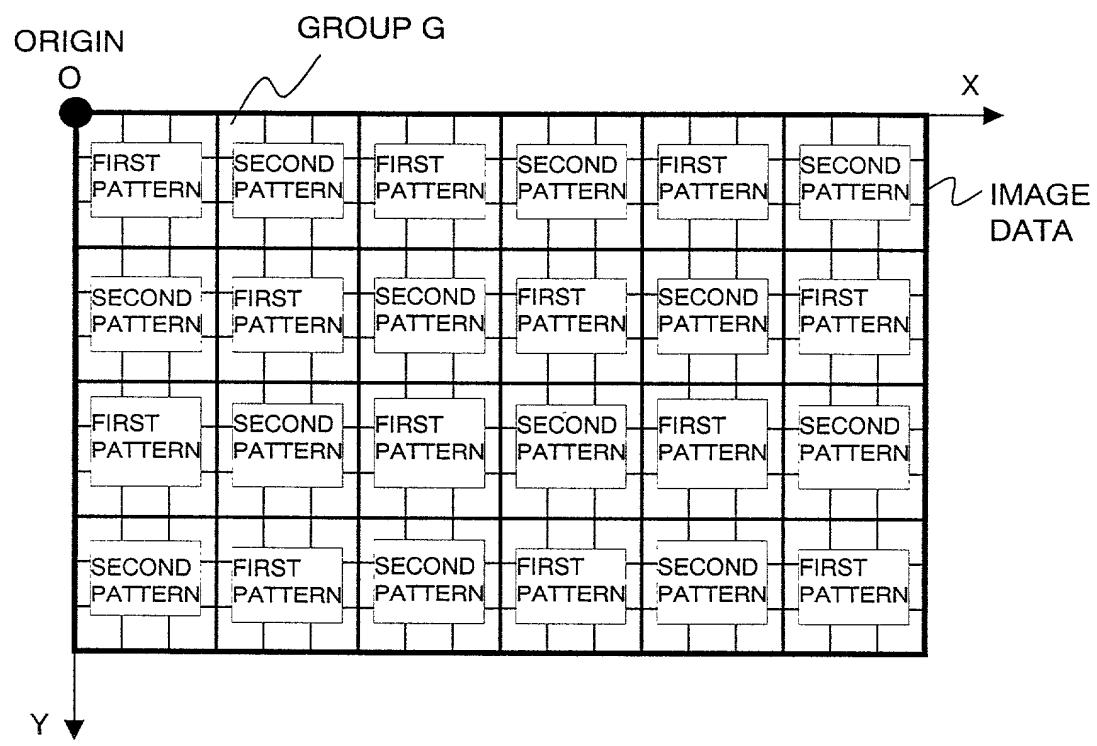


FIG.6

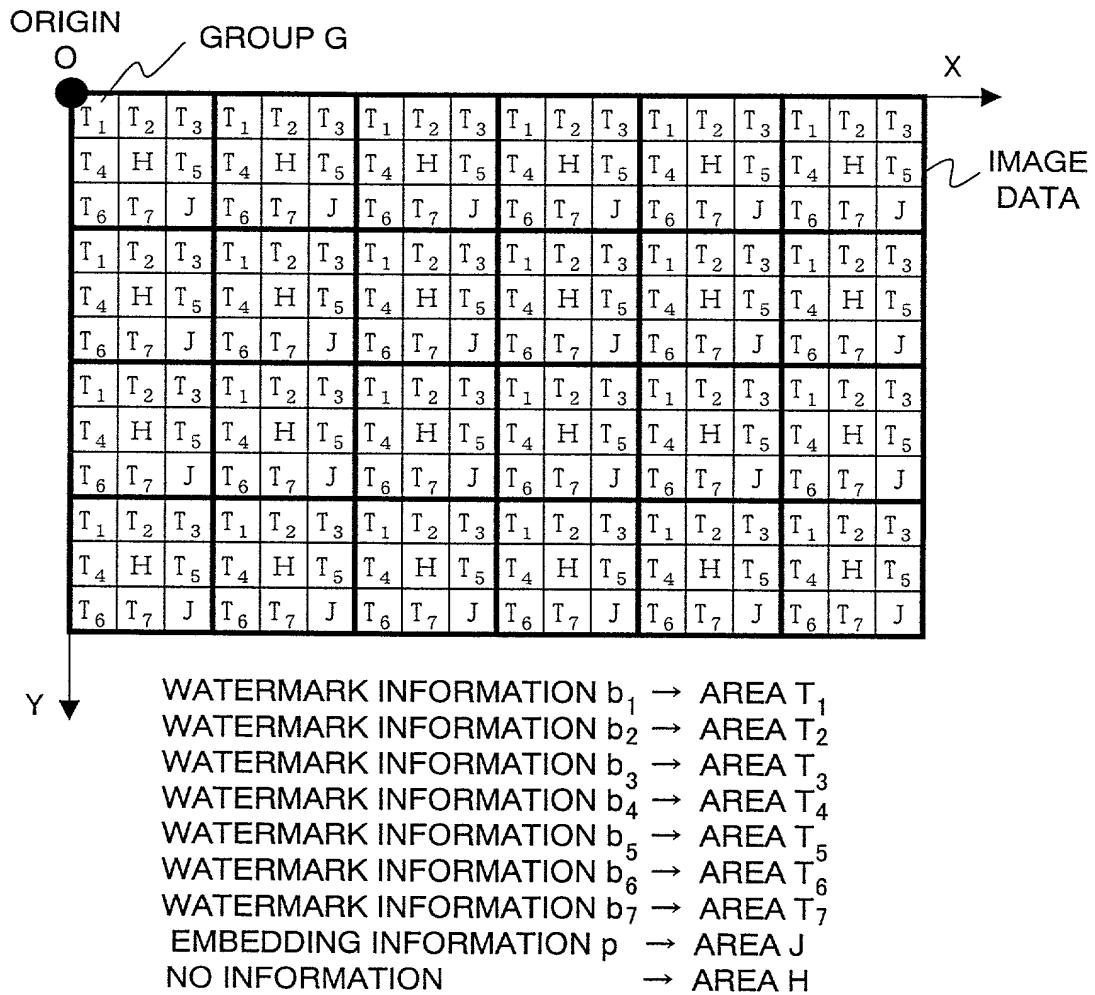


FIG.7

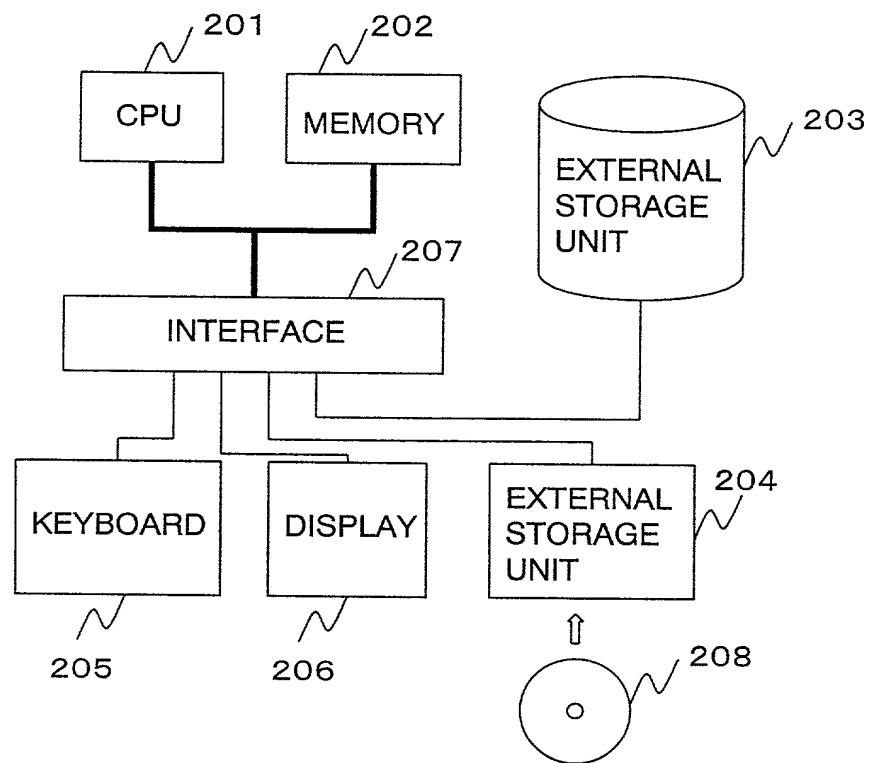


FIG.8

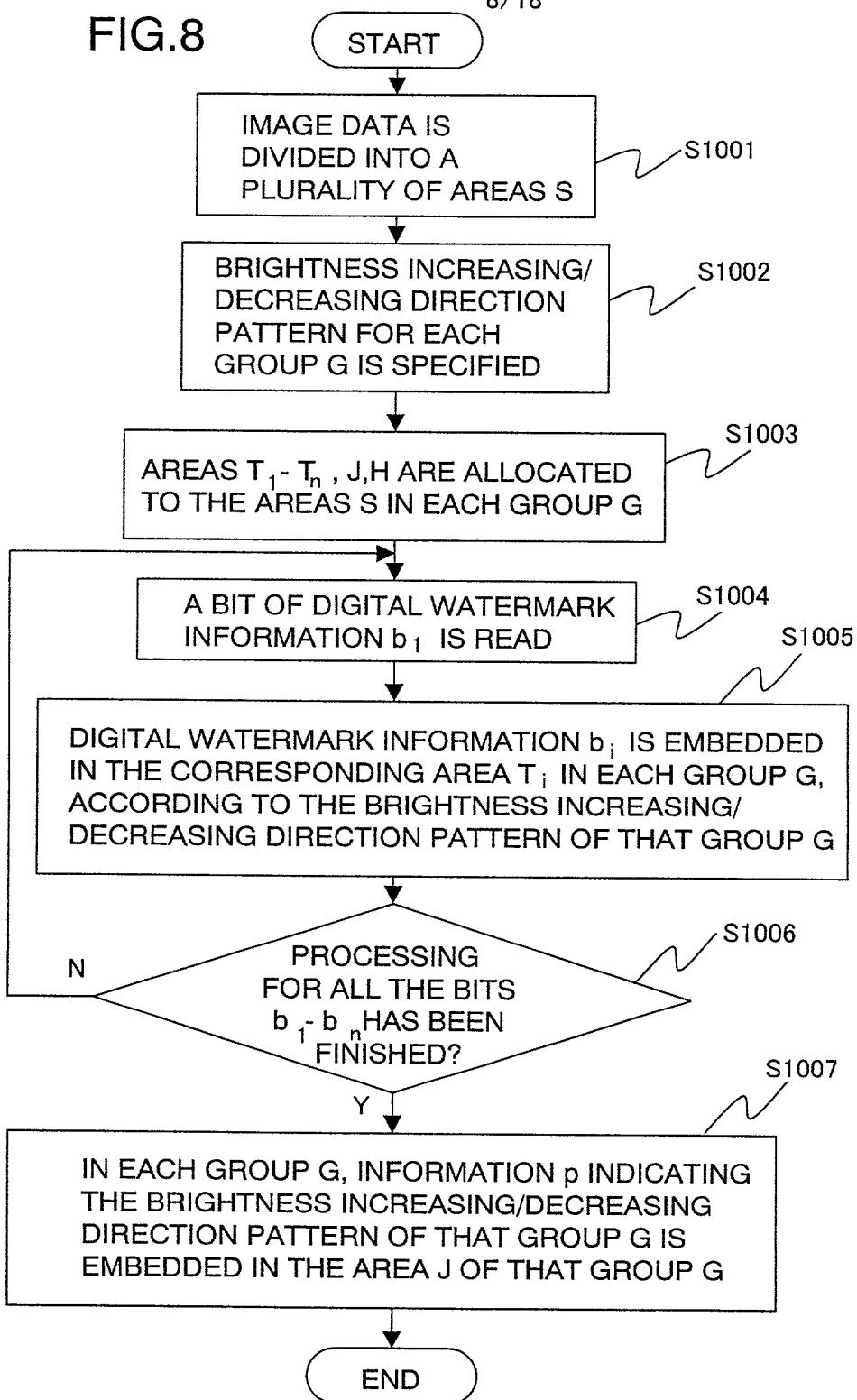


FIG.9

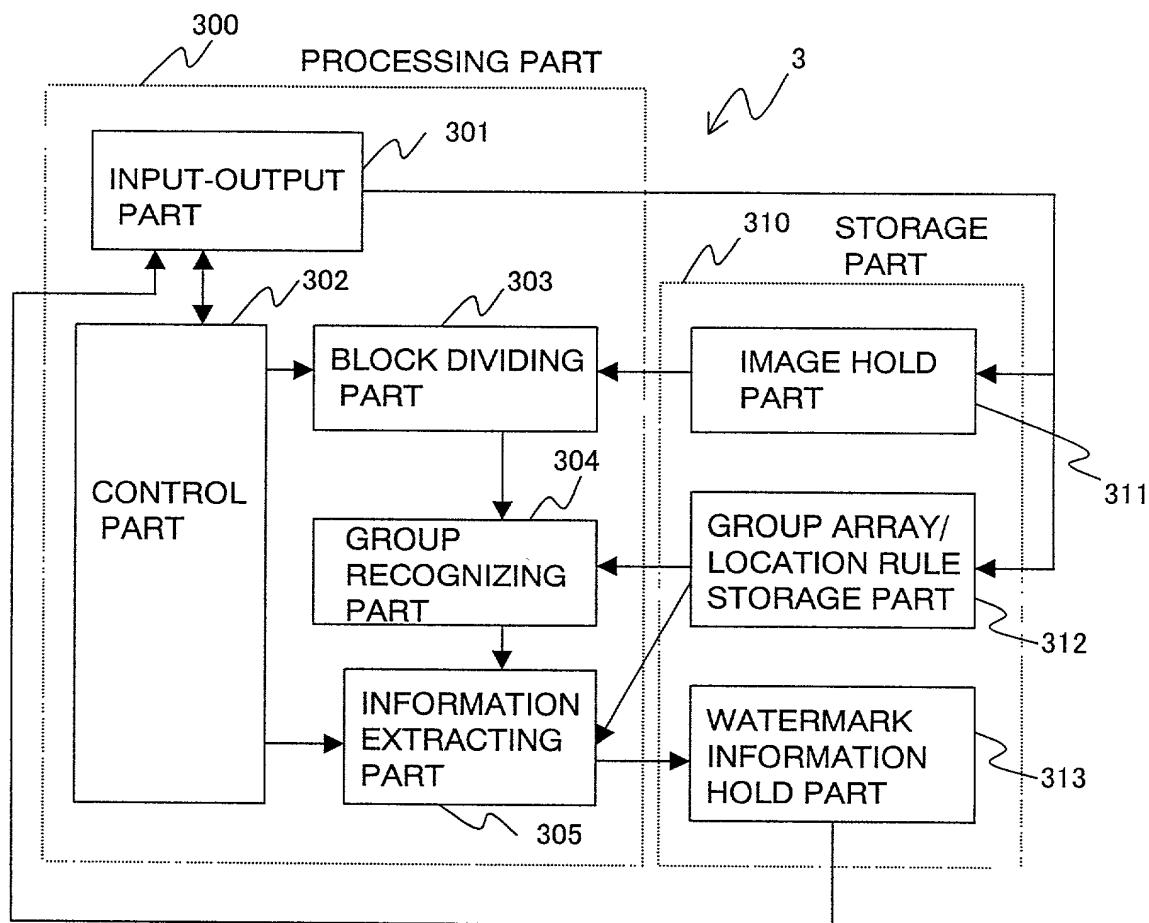


FIG.10

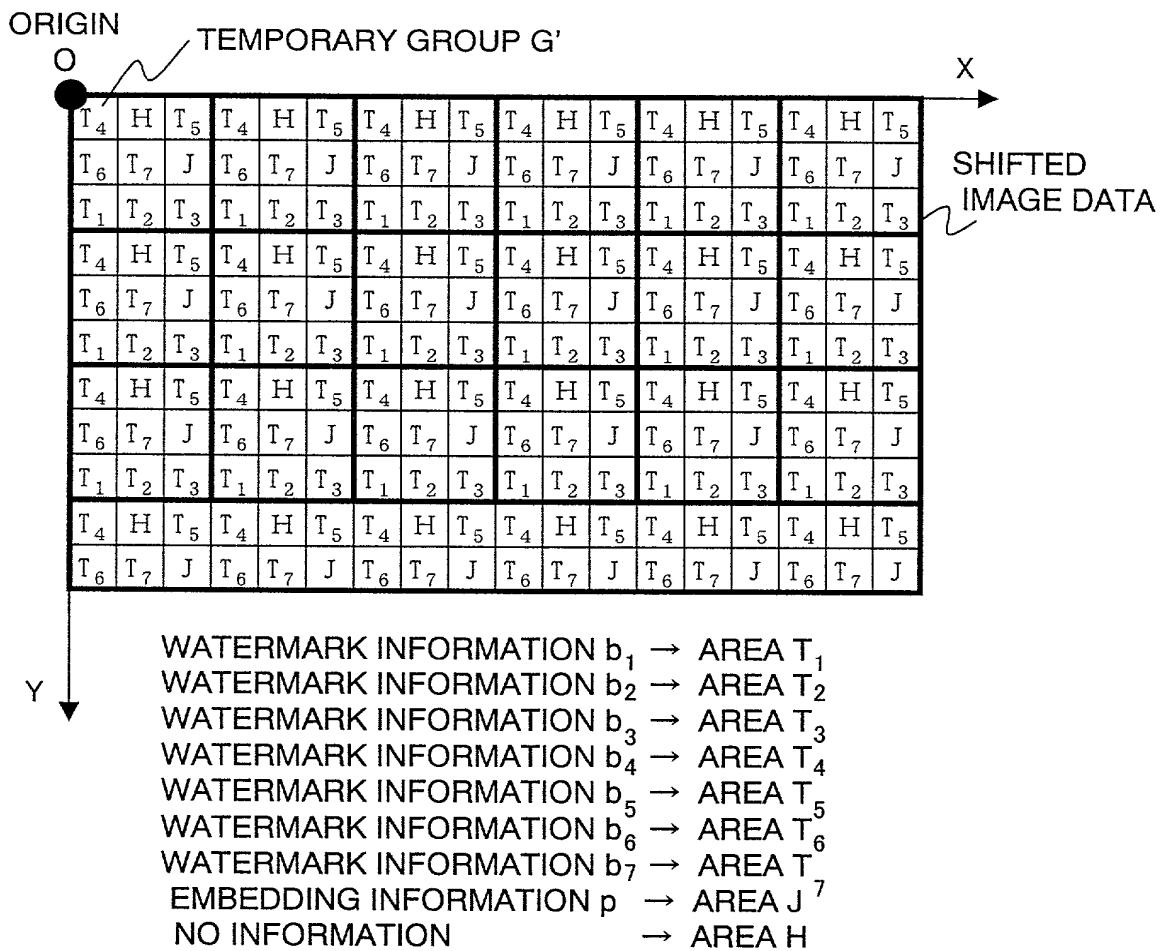


FIG.11

ORIGIN

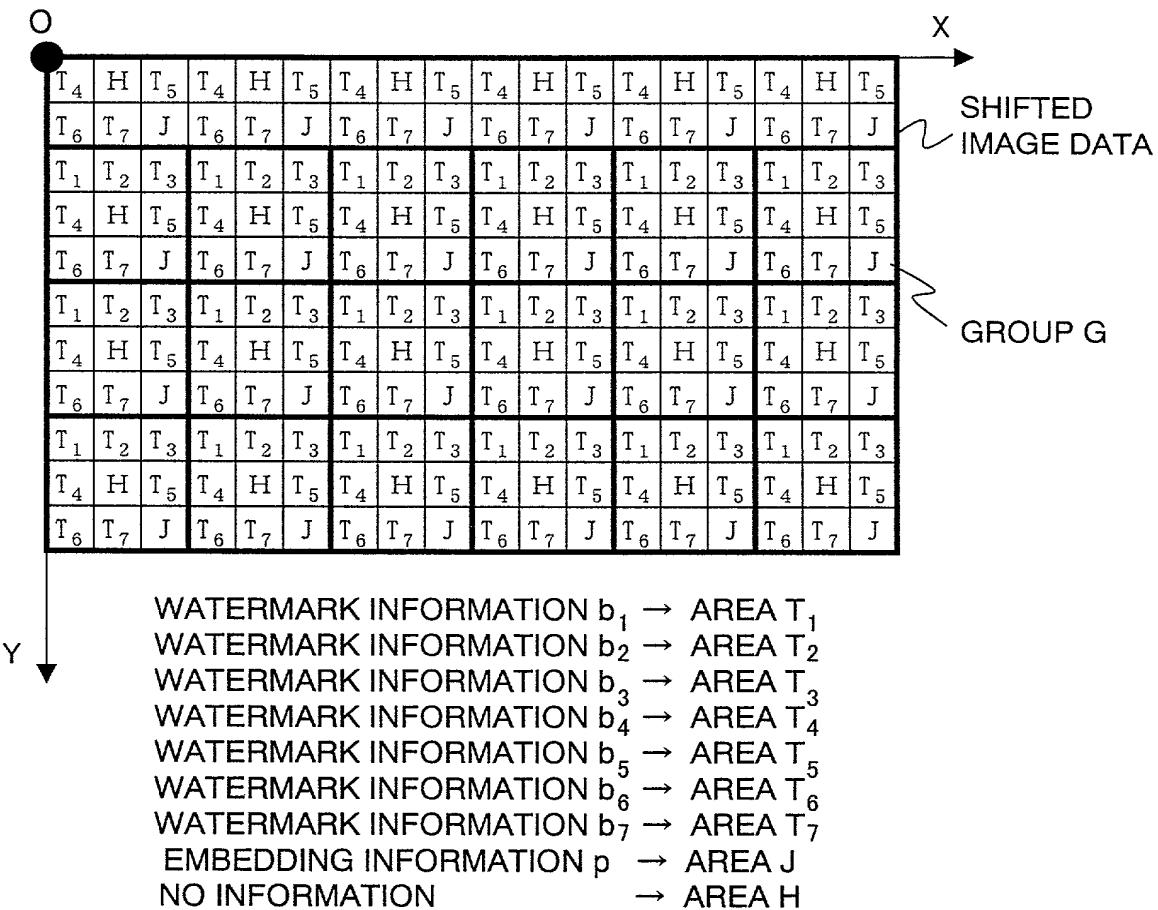


FIG.12

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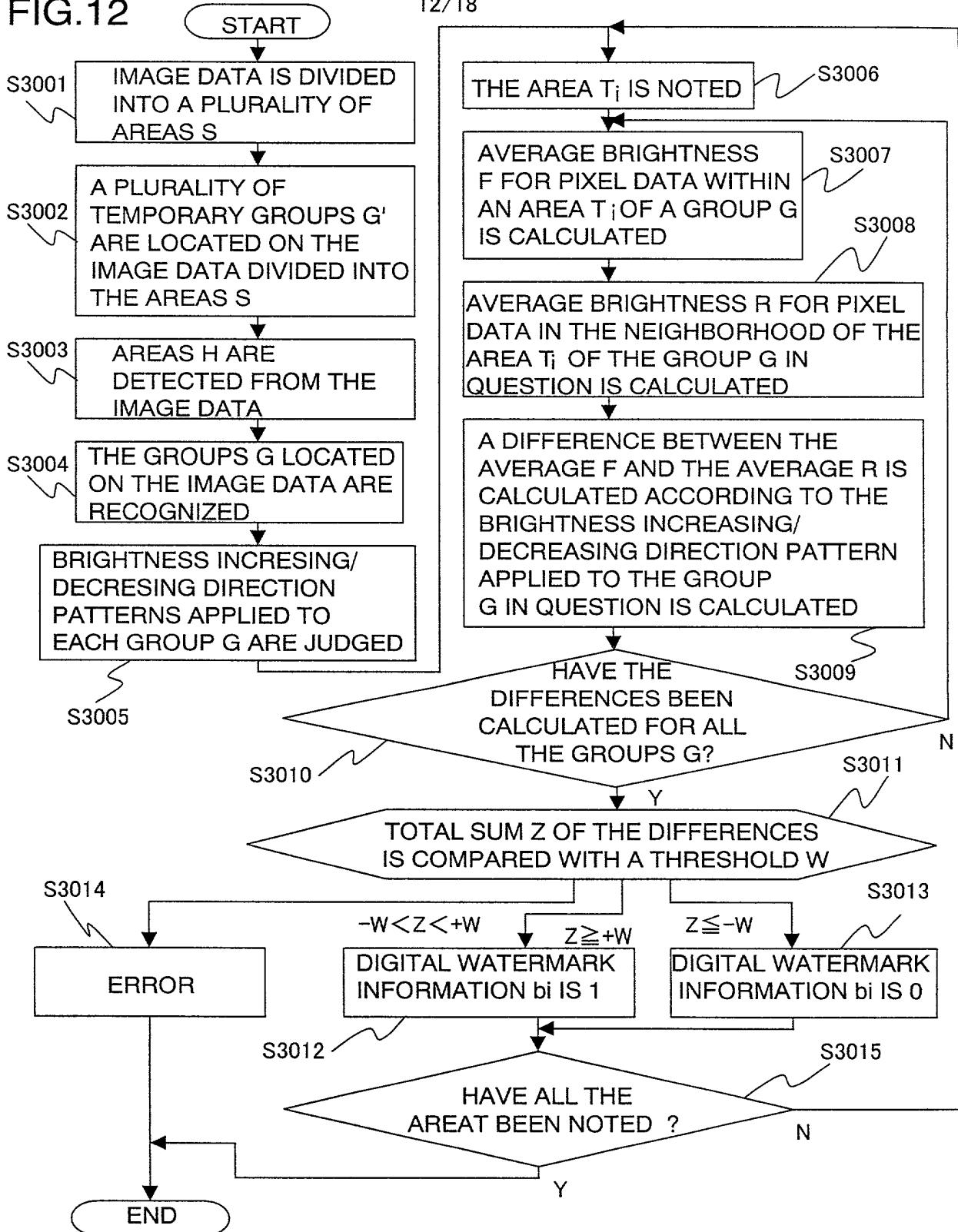


FIG.13A

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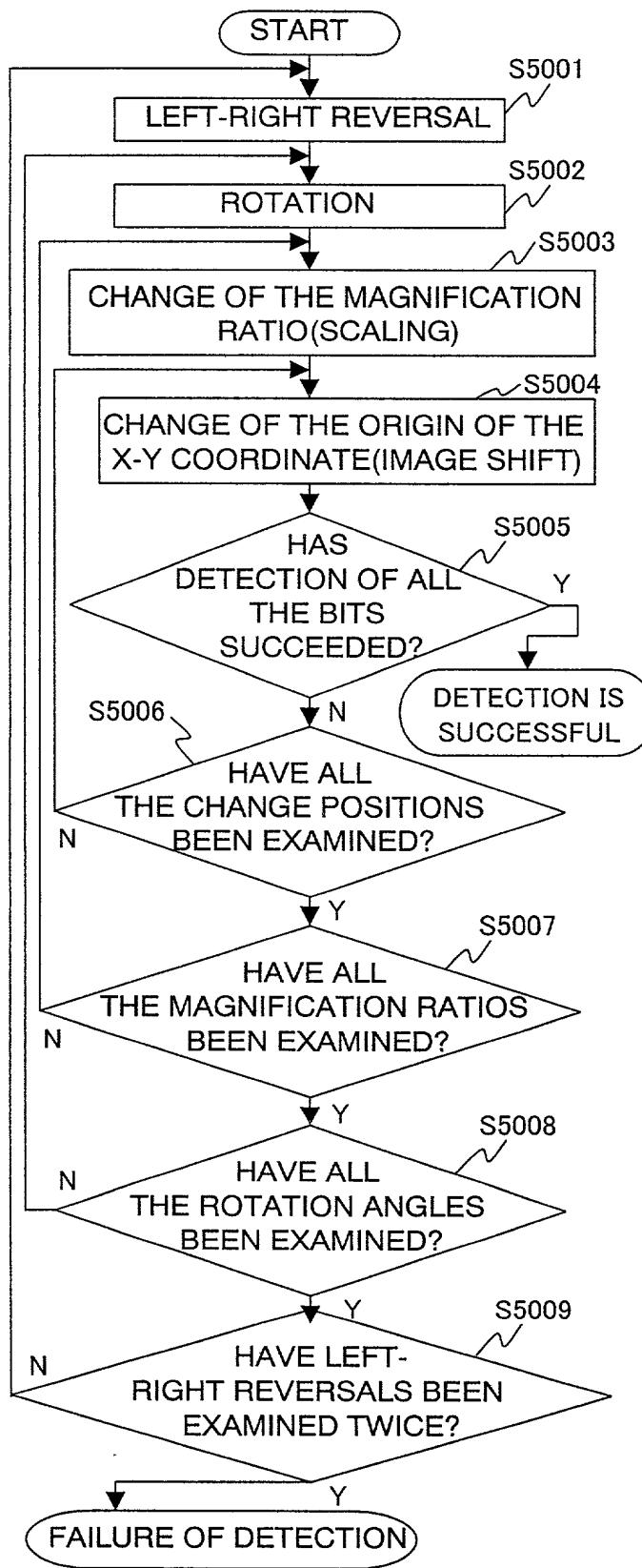


FIG.13B

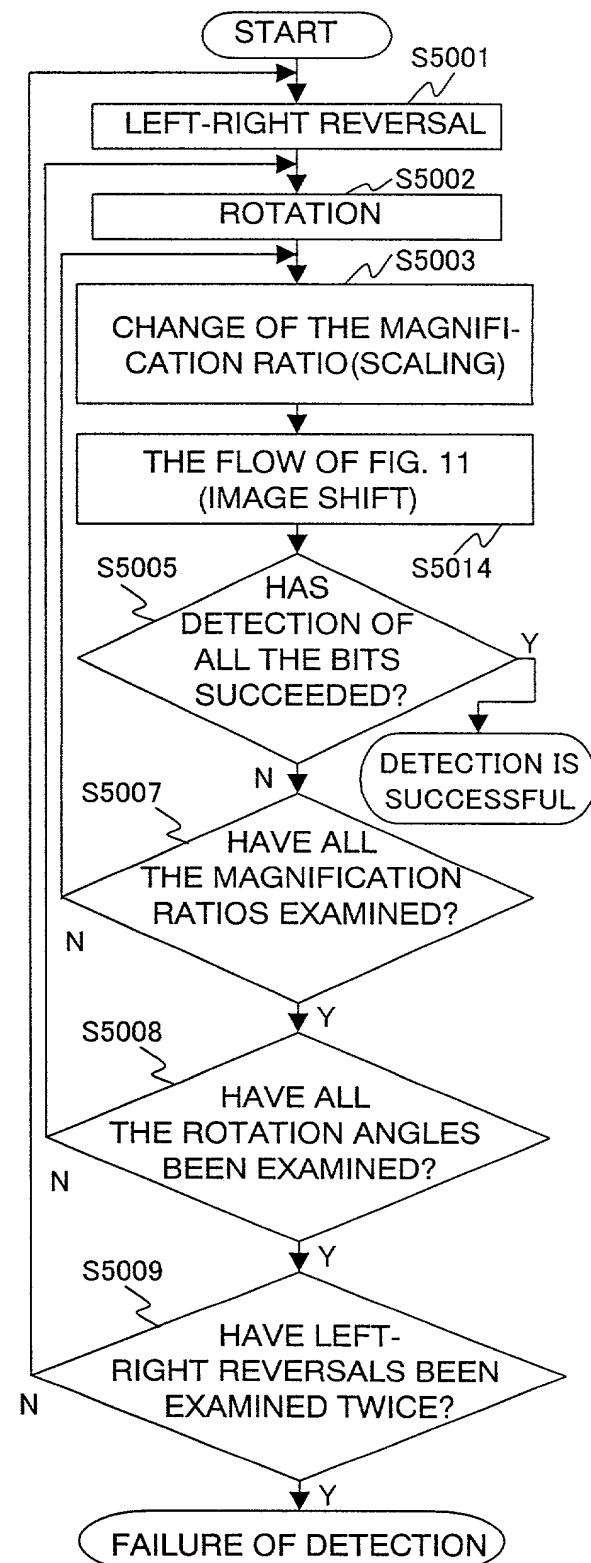
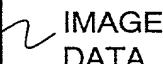


FIG.14

ORIGIN

O  GROUP G  X

T <sub>1</sub>	H	T <sub>2</sub>															
T <sub>3</sub>	H	H															
T <sub>4</sub>	T <sub>5</sub>	J															
T <sub>1</sub>	H	T <sub>2</sub>															
T <sub>3</sub>	H	H															
T <sub>4</sub>	T <sub>5</sub>	J															
T <sub>1</sub>	H	T <sub>2</sub>															
T <sub>3</sub>	H	H															
T <sub>4</sub>	T <sub>5</sub>	J															
T <sub>1</sub>	H	T <sub>2</sub>															
T <sub>3</sub>	H	H															
T <sub>4</sub>	T <sub>5</sub>	J															

Y

WATERMARK INFORMATION b<sub>1</sub> → AREA T<sub>1</sub>  
 WATERMARK INFORMATION b<sub>2</sub> → AREA T<sub>2</sub>  
 WATERMARK INFORMATION b<sub>3</sub> → AREA T<sub>3</sub>  
 WATERMARK INFORMATION b<sub>4</sub> → AREA T<sub>4</sub>  
 WATERMARK INFORMATION b<sub>5</sub> → AREA T<sub>5</sub>  
 WATERMARK INFORMATION b<sub>6</sub> → AREA T<sub>6</sub>  
 WATERMARK INFORMATION b<sub>7</sub> → AREA T<sub>7</sub>  
 EMBEDDING INFORMATION p → AREA J  
 NO INFORMATION → AREA H

FIG.15

ORIGIN

O GROUP G

T <sub>2</sub>	H	T <sub>1</sub>															
H	H	T <sub>3</sub>															
J	T <sub>5</sub>	T <sub>4</sub>															
T <sub>2</sub>	H	T <sub>1</sub>															
H	H	T <sub>3</sub>															
J	T <sub>5</sub>	T <sub>4</sub>															
T <sub>2</sub>	H	T <sub>1</sub>															
H	H	T <sub>3</sub>															
J	T <sub>5</sub>	T <sub>4</sub>															
T <sub>2</sub>	H	T <sub>1</sub>															
H	H	T <sub>3</sub>															
J	T <sub>5</sub>	T <sub>4</sub>															

X

LEFT-RIGHT-  
REVERSED  
IMAGE DATA

Y

WATERMARK INFORMATION  $b_1 \rightarrow$  AREA T<sub>1</sub>  
 WATERMARK INFORMATION  $b_2 \rightarrow$  AREA T<sub>2</sub>  
 WATERMARK INFORMATION  $b_3 \rightarrow$  AREA T<sub>3</sub>  
 WATERMARK INFORMATION  $b_4 \rightarrow$  AREA T<sub>4</sub>  
 WATERMARK INFORMATION  $b_5 \rightarrow$  AREA T<sub>5</sub>  
 WATERMARK INFORMATION  $b_6 \rightarrow$  AREA T<sub>6</sub>  
 WATERMARK INFORMATION  $b_7 \rightarrow$  AREA T<sub>7</sub>  
 EMBEDDING INFORMATION p → AREA J  
 NO INFORMATION → AREA H

FIG.16

ORIGIN

O

GROUP G

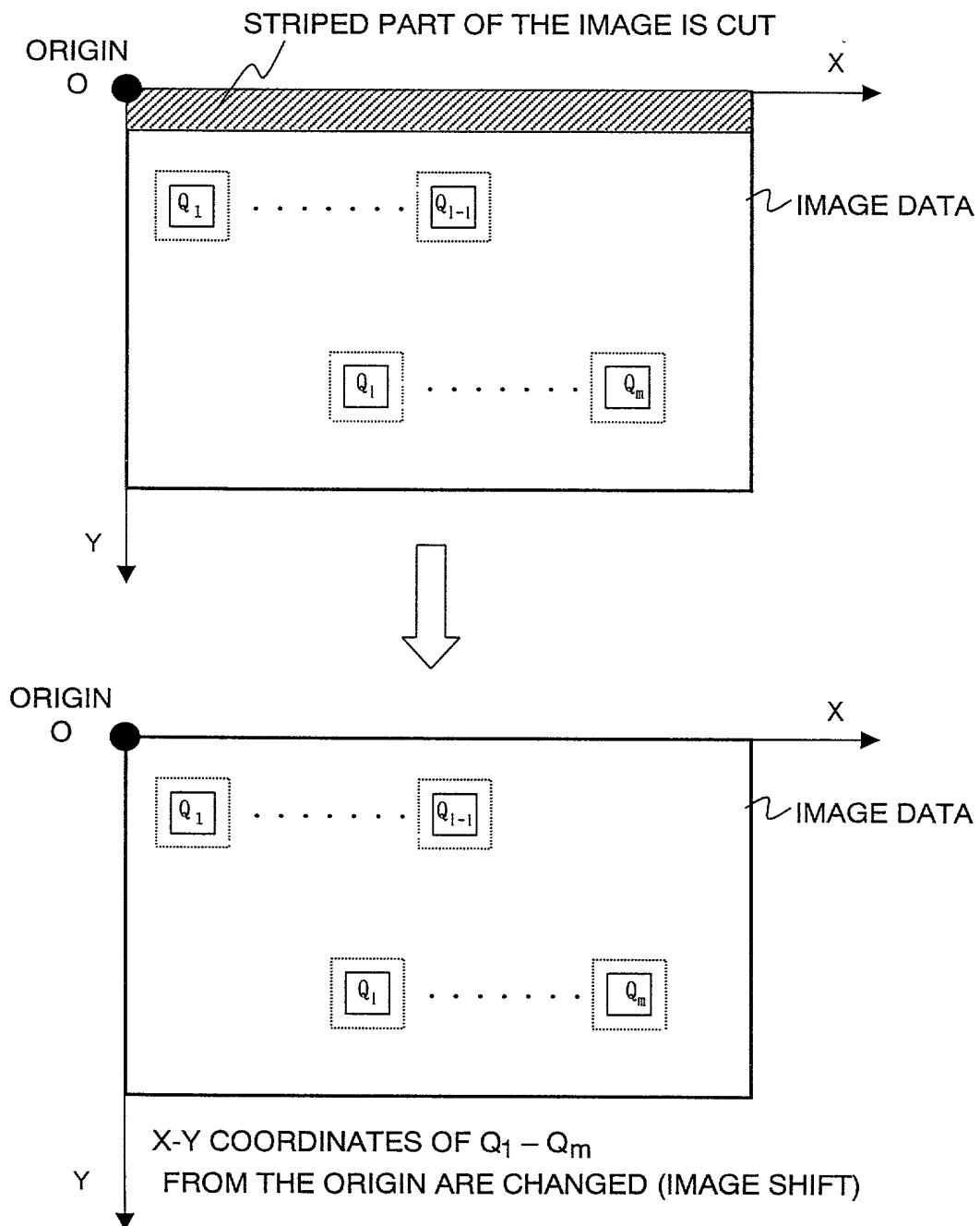
J	T <sub>5</sub>	T <sub>4</sub>															
H	H	T <sub>3</sub>															
T <sub>2</sub>	H	T <sub>1</sub>															
J	T <sub>5</sub>	T <sub>4</sub>															
H	H	T <sub>3</sub>															
T <sub>2</sub>	H	T <sub>1</sub>															
J	T <sub>5</sub>	T <sub>4</sub>															
H	H	T <sub>3</sub>															
T <sub>2</sub>	H	T <sub>1</sub>															
J	T <sub>5</sub>	T <sub>4</sub>															
H	H	T <sub>3</sub>															
T <sub>2</sub>	H	T <sub>1</sub>															

180-DEGREE-  
ROTATED  
IMAGE DATA

WATERMARK INFORMATION  $b_1 \rightarrow$  AREA T<sub>1</sub>  
 WATERMARK INFORMATION  $b_2 \rightarrow$  AREA T<sub>2</sub>  
 WATERMARK INFORMATION  $b_3 \rightarrow$  AREA T<sub>3</sub>  
 WATERMARK INFORMATION  $b_4 \rightarrow$  AREA T<sub>4</sub>  
 WATERMARK INFORMATION  $b_5 \rightarrow$  AREA T<sub>5</sub>  
 WATERMARK INFORMATION  $b_6 \rightarrow$  AREA T<sub>6</sub>  
 WATERMARK INFORMATION  $b_7 \rightarrow$  AREA T<sub>7</sub>  
 EMBEDDING INFORMATION p → AREA J  
 NO INFORMATION → AREA H

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FIG. 17

FIG.18



## Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

 \_\_月\_\_日に提出され、米国出願番号または特許協定条約国際出願番号を\_\_\_\_\_とし、  
(該当する場合) \_\_\_\_\_に訂正されました。 was filed on  
as United States Application Number or  
PCT International Application Number  
\_\_\_\_\_ and was amended on  
\_\_\_\_\_ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

## Japanese Language Declaration (日本語宣言書)

私は、米国法典第35編119条(a) - (d)項又は365条(b)項に基き下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約365(a)項に基く国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示している。

### Prior Foreign Application(s)

外国での先行出願

11-153672	Japan
(Number) (番号)	(Country) (国名)
_____	_____
(Number) (番号)	(Country) (国名)

私は、第35編米国法典119条(e)項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

(Application No.) (出願番号)	(Filing Date) (出願日)
_____	_____

私は、下記の米国法典第35編120条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基く権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

(Application No.) (出願番号)	(Filing Date) (出願日)
_____	_____

私は、私自身の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基づく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed  
優先権主張なし

1/June/1999	<input type="checkbox"/>
(Day/Month/Year Filed) (出願年月日)	

_____	<input type="checkbox"/>
(Day/Month/Year Filed) (出願年月日)	

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)
_____	_____

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Status: Patented, Pending, Abandoned)  
(現況: 特許許可済、係属中、放棄済)

(Status: Patented, Pending, Abandoned)  
(現況: 特許許可済、係属中、放棄済)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

### Japanese Language Declaration (日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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発明者の署名	日付	Inventor's signature <i>Kousuke Anzai</i>	Date 21/4/2000
住所	Residence Fujisawa, Japan		
国籍	Citizenship Japan		
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan		

(第二以降の共同発明者についても同様に記載し、署名すること)  
(Supply similar information and signature for second and subsequent joint inventors.)

第二共同発明者	Full name of second joint inventor, if any Isao Echizen	
第二共同発明者の署名	日付	Second inventor's signature Date <i>Isao Echizen</i> 8/5/2000
住所	Residence Yokohama, Japan	
国籍	Citizenship Japan	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第三共同発明者	Full name of third joint inventor, if any Hiroshi YOSHIURA	
第三共同発明者の署名	日付	Third inventor's signature Date <i>Hiroshi Yoshiura</i> 8/5/2000
住所	Residence Tokyo, Japan	
国籍	Citizenship Japan	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第四共同発明者	Full name of fourth joint inventor, if any Shinobu EIKAWA	
第四共同発明者の署名	日付	Fourth inventor's signature Date <i>Shinobu Eikawa</i> 9/5/2000
住所	Residence Yokohama, Japan	
国籍	Citizenship Japan	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第五共同発明者	Full name of fifth joint inventor, if any	
第五共同発明者の署名	日付	Fifth inventor's signature Date
住所	Residence	
国籍	Citizenship	
私書箱	Post Office Address	

(第六以降の共同発明者についても同様に記載し、署名すること)

(Supply similar information and signature for sixth and subsequent joint inventors.)